

The Estuary Geometry is Not Static: Natural and Human Influence on Salinity Trends

Chris Enright, Aaron Miller, Brad Tom
Suisun Marsh Branch – DWR
October 6, 2004

Dynamic!

The Estuary Geometry is ~~Not Static~~:
Natural and Human Influence
on Salinity Trends

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Take home's

- Outflow and salinity trends are minimal since 1921. Most variability explained by climate.
- The physical geometry of the estuary dissipates tidal energy and disperses salt.
- The estuary geometry changes through “natural” and human influence.
- The salinity regime of the estuary depends primarily on geometry.

This talk

1. Outflow and salinity trends
2. Effect of geometry on salinity transport
3. “Natural” vs. human influence on geometry, and therefore, salinity:

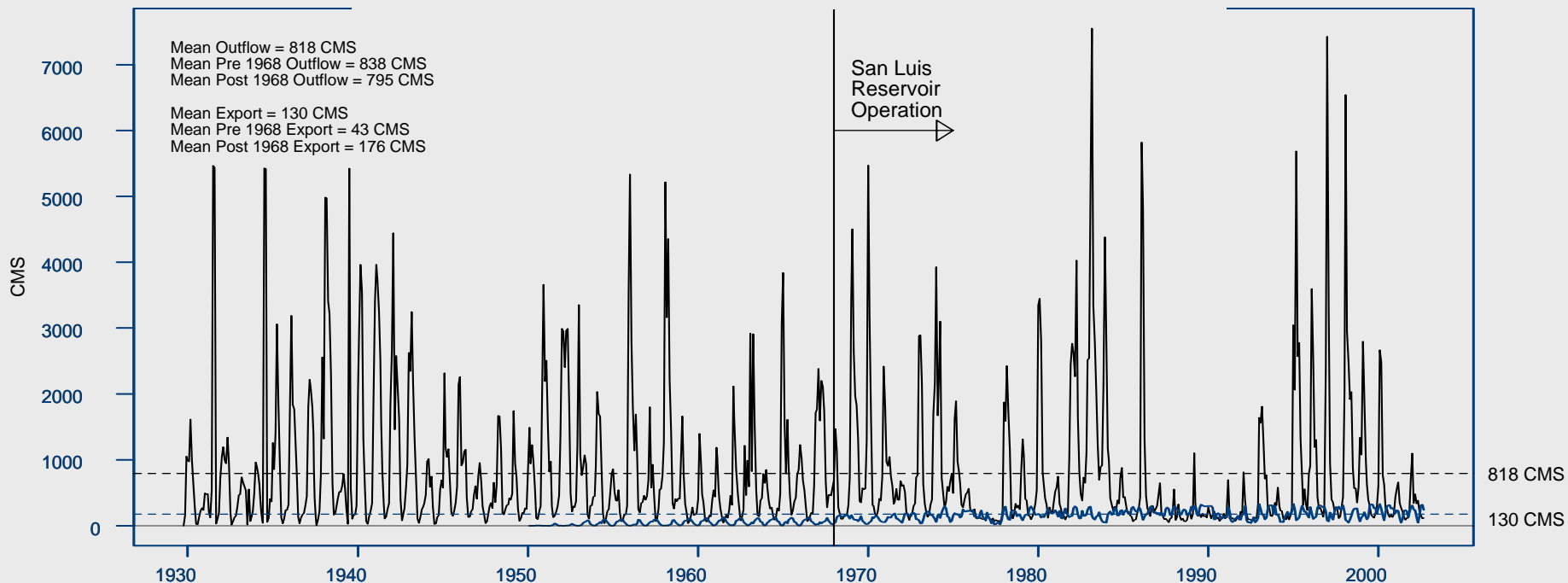
Examples:

- Gold rush sediment erosion from Suisun Bay
- Delta channel “cuts”
- Sea level rise
- Sacramento & SJR ship channels

1. Outflow and Salinity Trends

- Delta outflow ~22% less than it would be.
- No precipitation trend. (1921-2002)

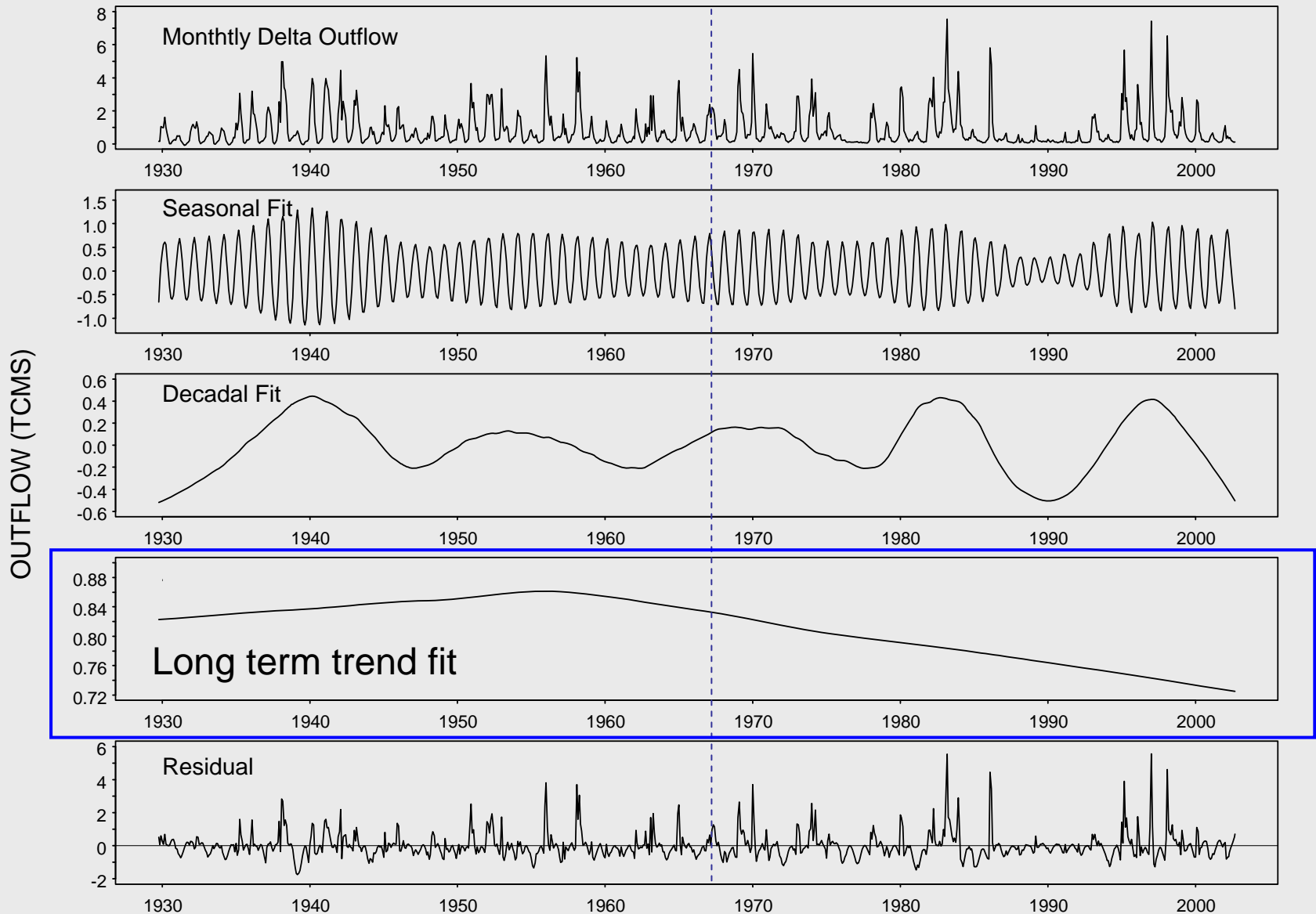
Historical Outflow and Total Export



1. Outflow and Salinity Trends

Delta Outflow

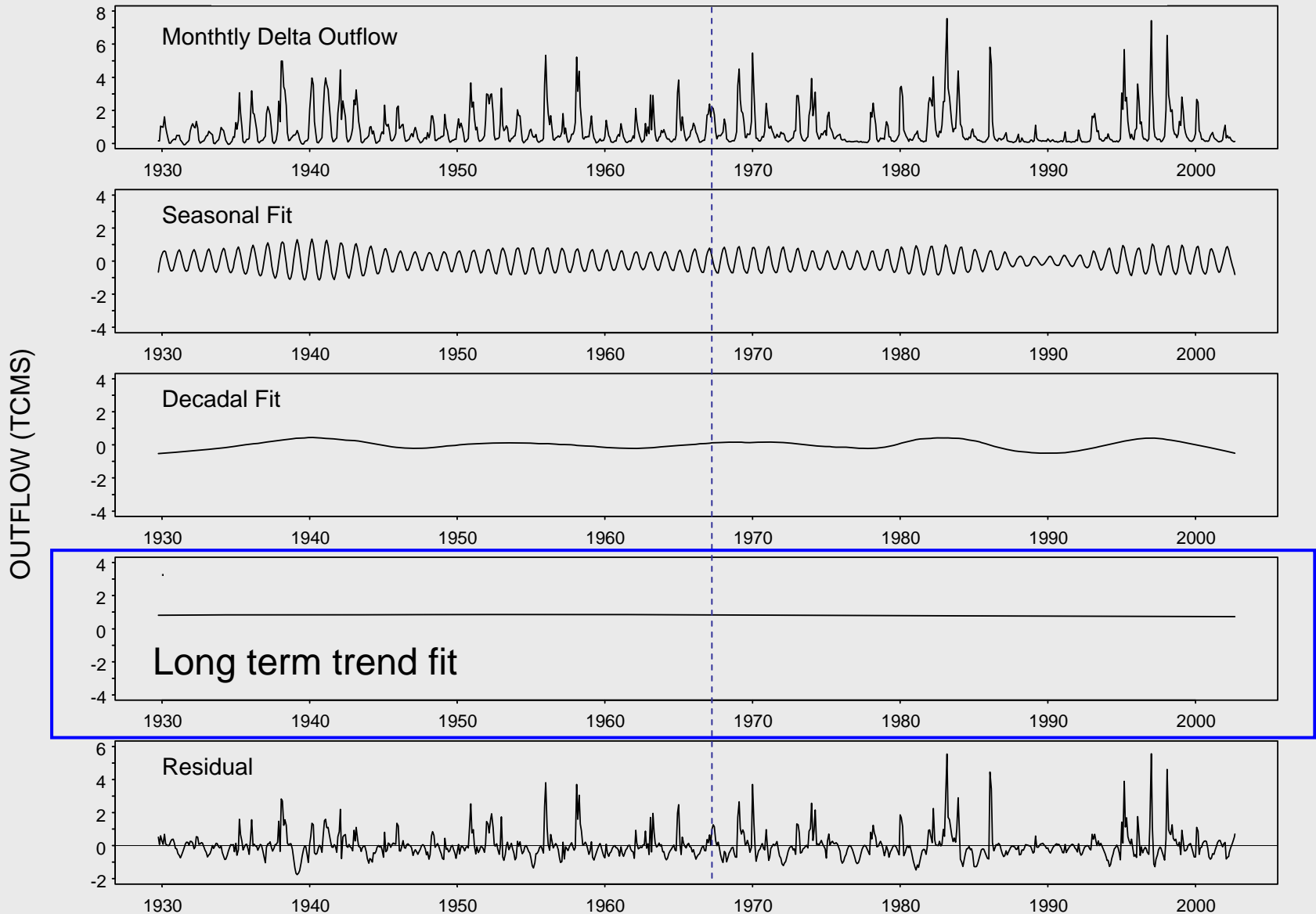
Seasonal LOESS trend decomposition



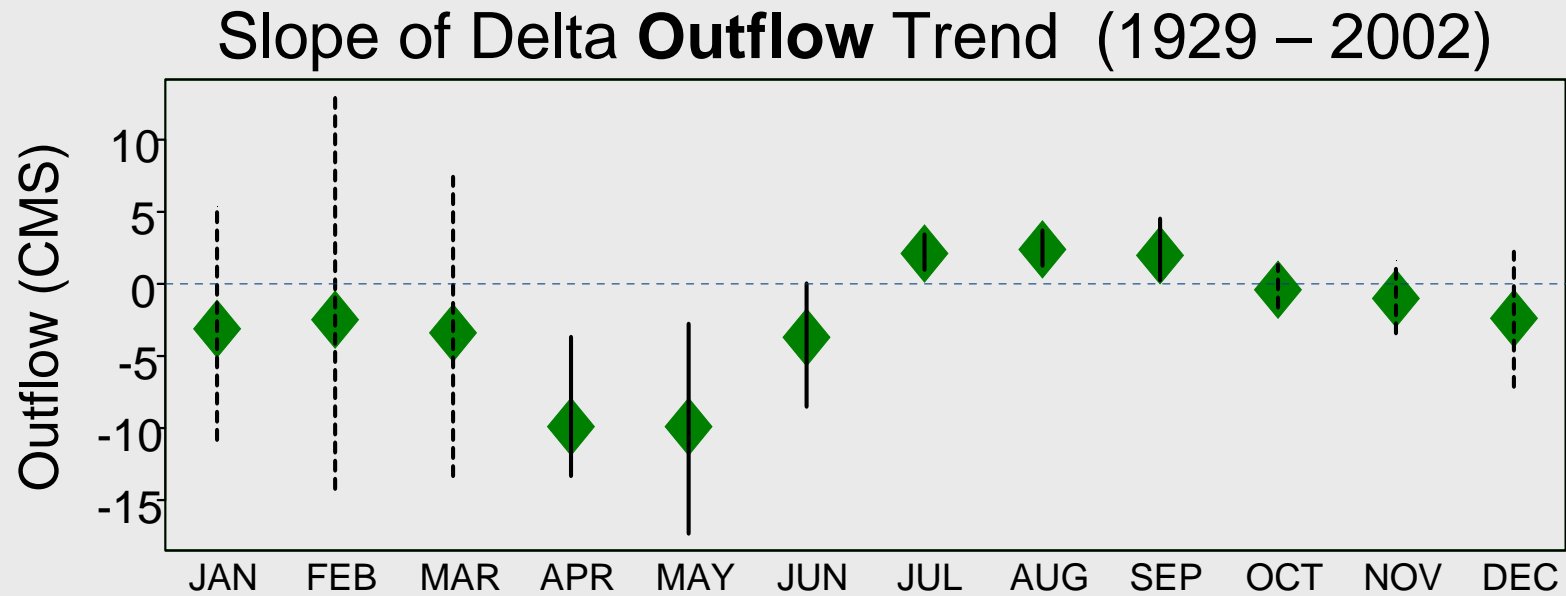
1. Outflow and Salinity Trends

Delta Outflow

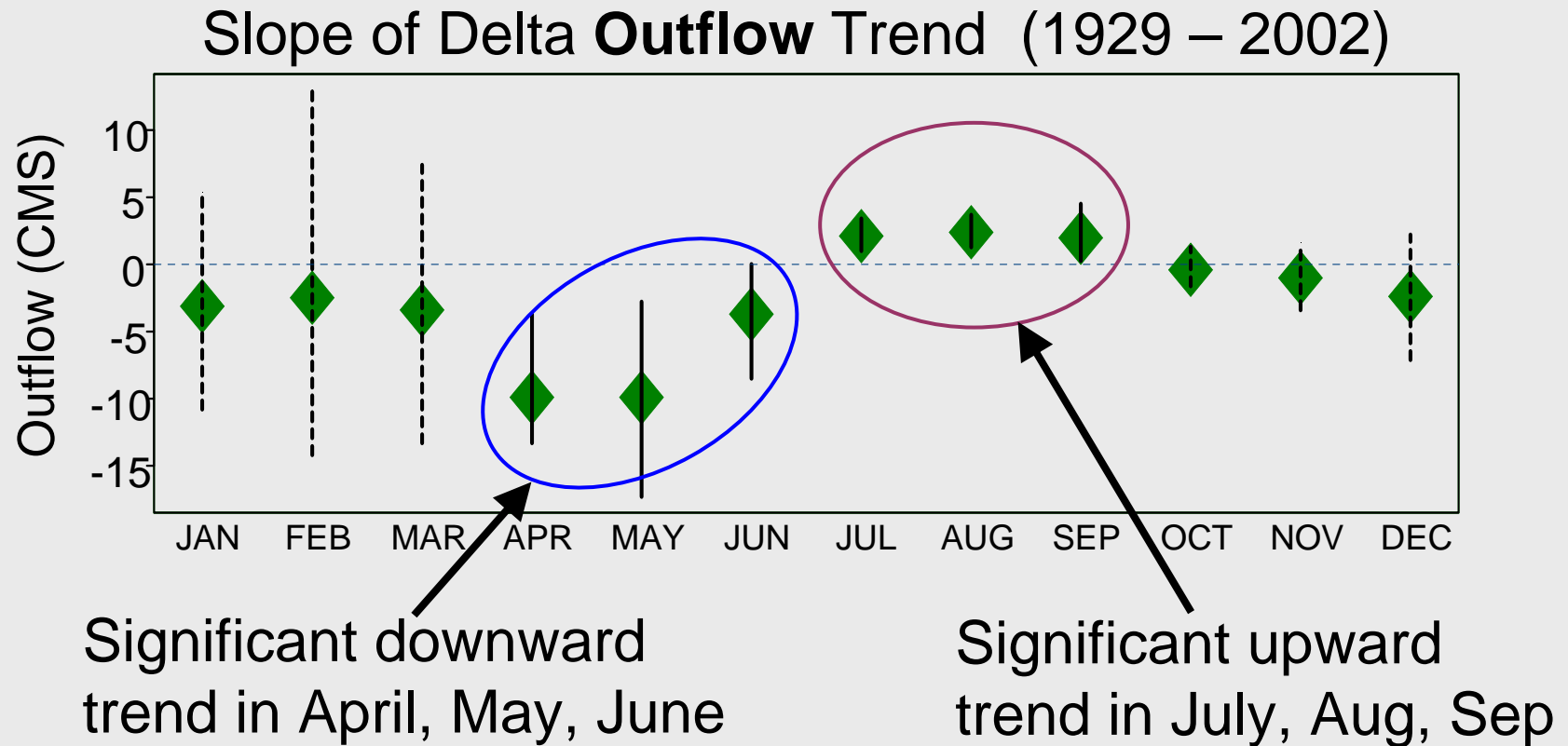
Seasonal LOESS trend decomposition



Water projects have re-distributed outflow *seasonally*

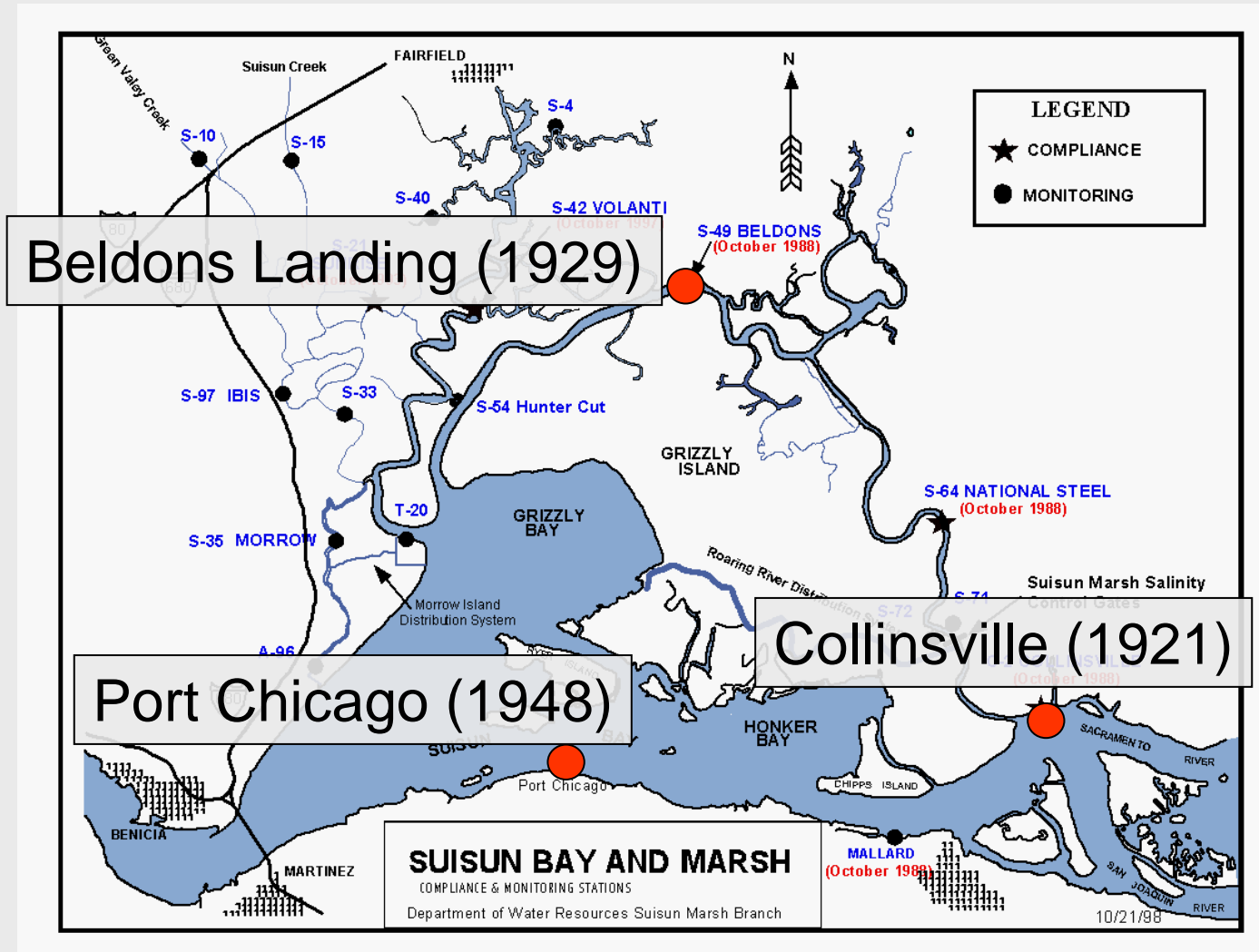


Water projects have re-distributed outflow *seasonally*



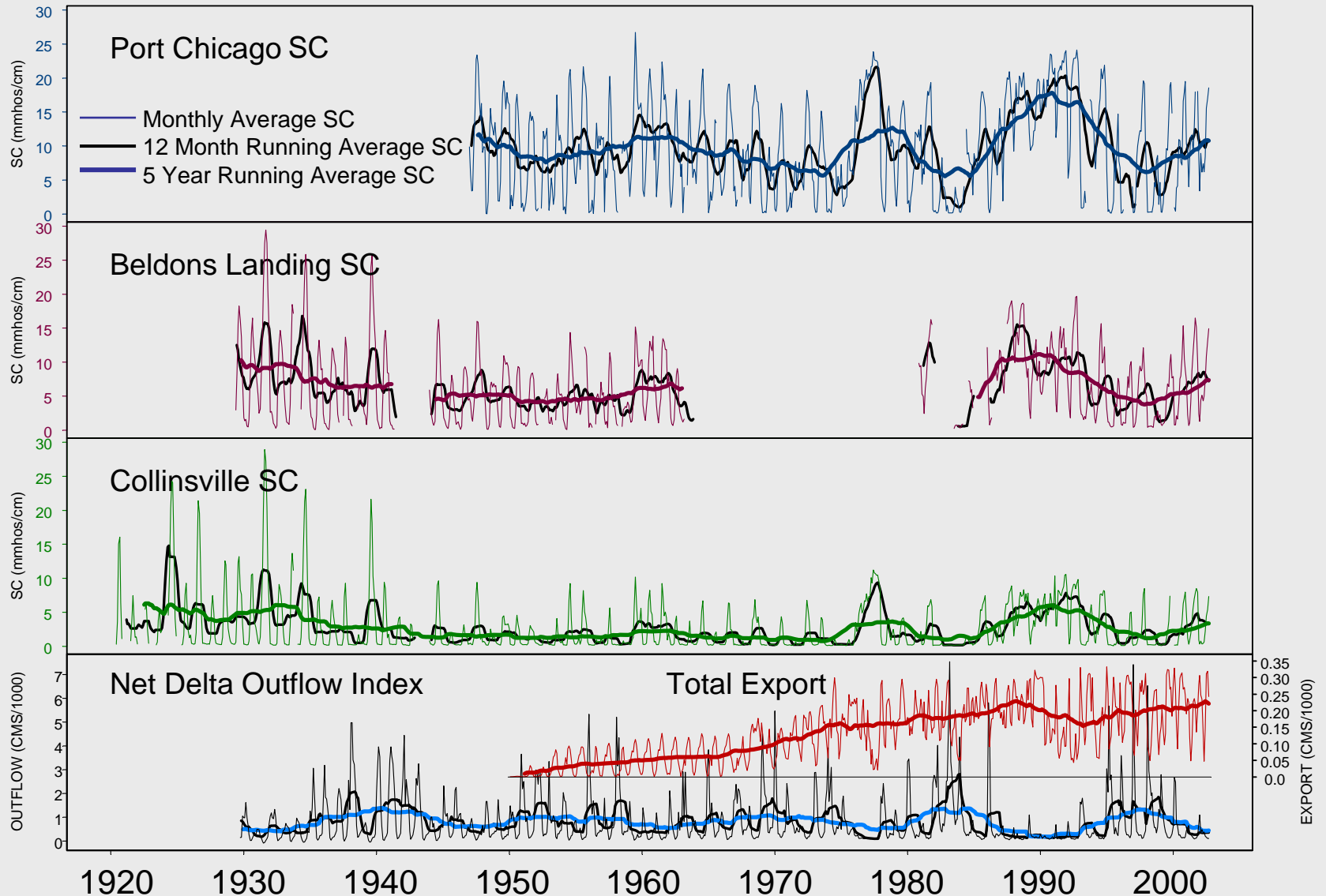
1. Outflow and Salinity Trends

Suisun Marsh/Bay salinity data



1. Outflow and Salinity Trends

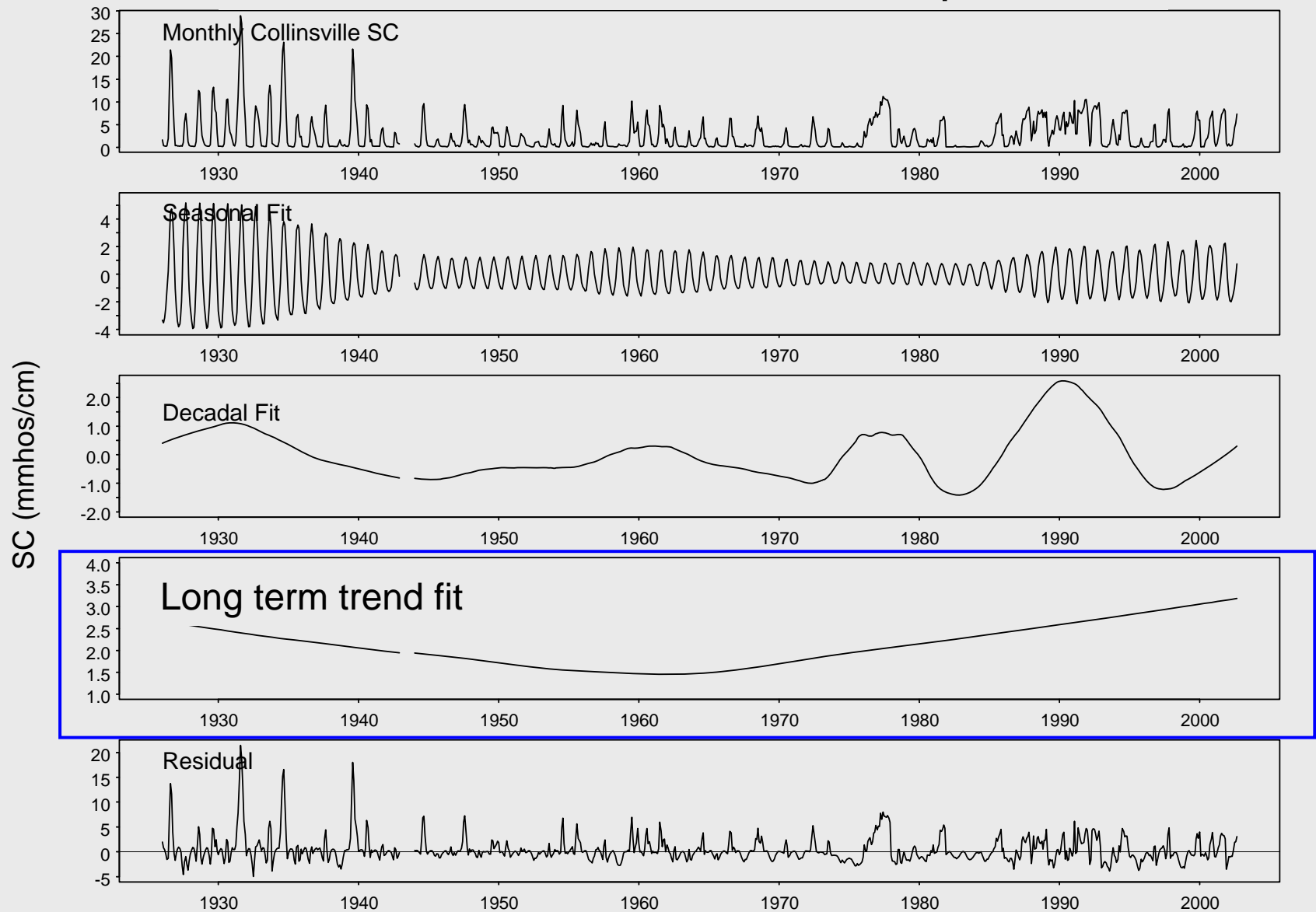
Historical Suisun Marsh/Bay Salinity: 1921 - 2002



1. Outflow and Salinity Trends

Collinsville SC

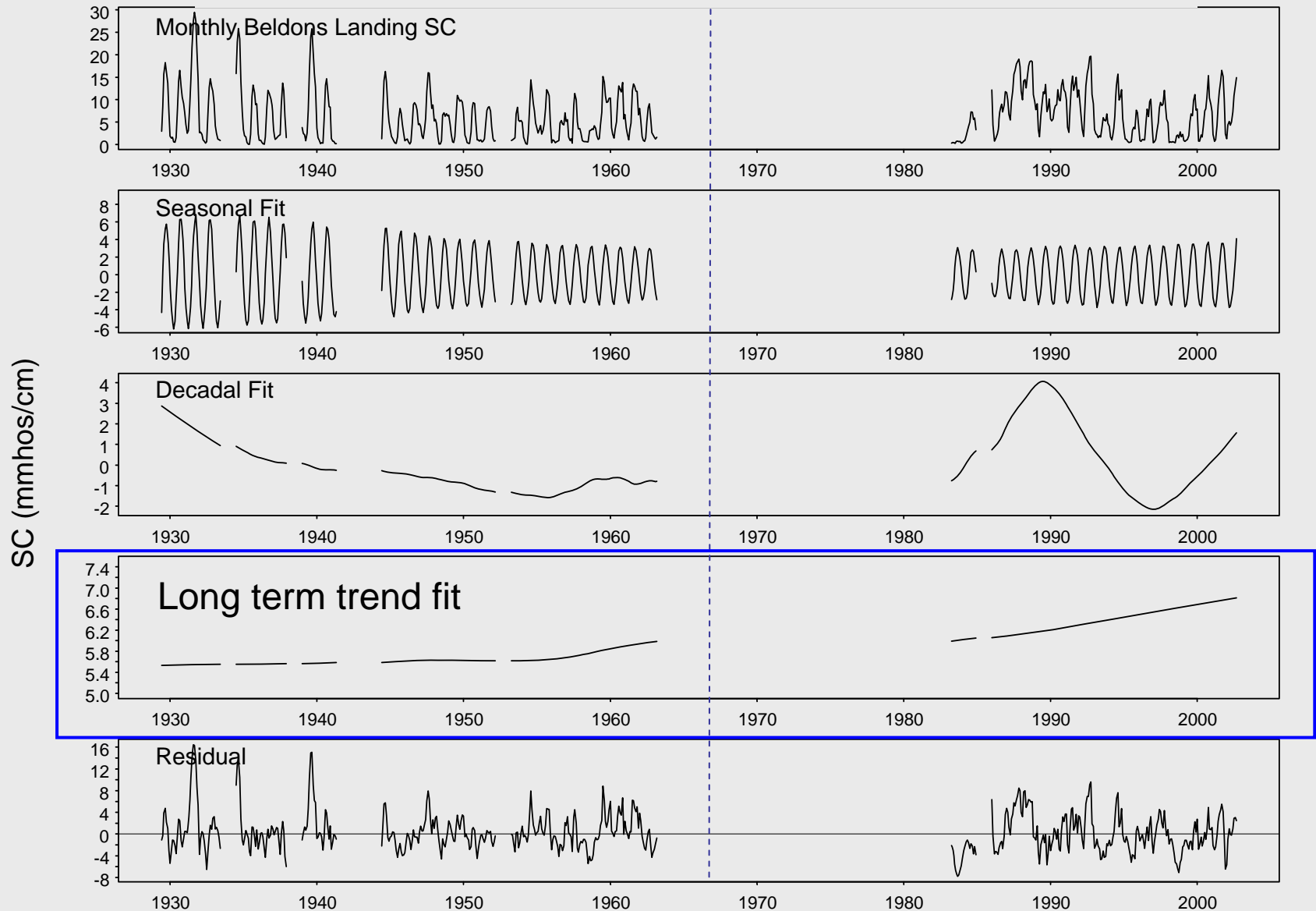
Seasonal LOESS trend decomposition



1. Outflow and Salinity Trends

Beldons Landing SC

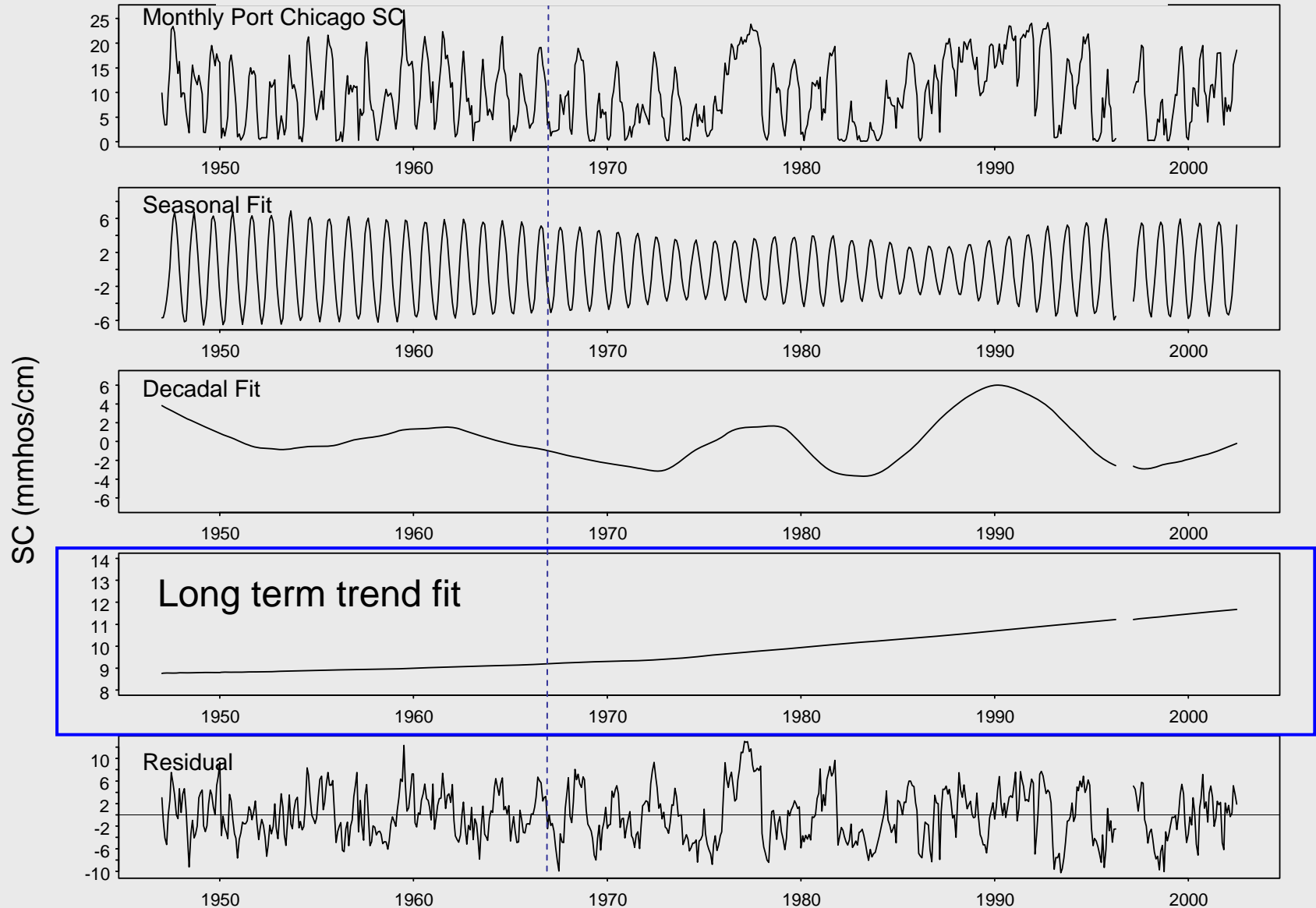
Seasonal LOESS trend decomposition



1. Outflow and Salinity Trends

Port Chicago SC

Seasonal LOESS trend decomposition



Outflow and salinity trends:

- Long-term outflow trends are minimal
- Long-term SB salinity up 5-10%
- Seasonal redistribution of outflow
- Seasonal salinity is coherent with outflow

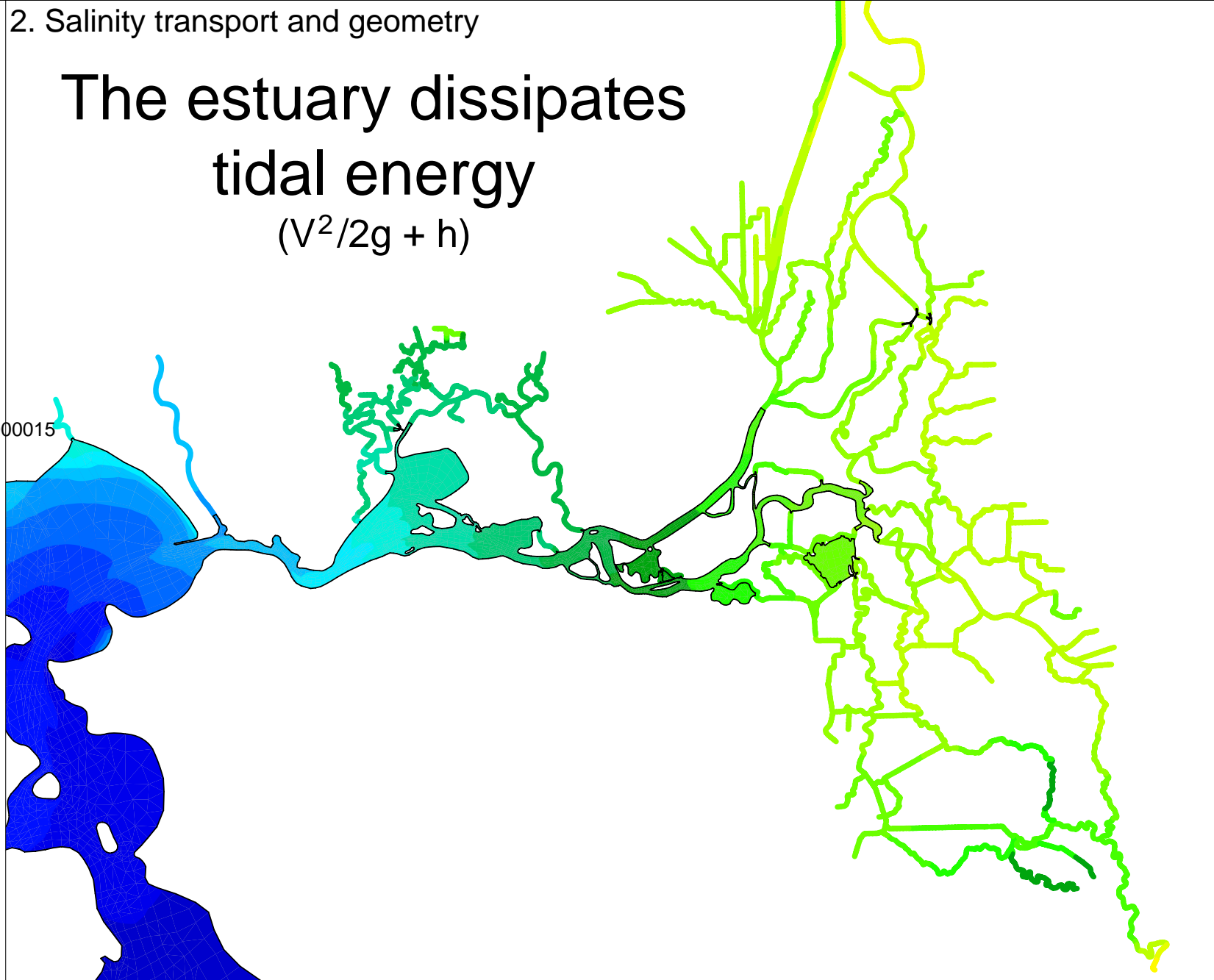
2. Salinity transport and geometry

- The estuary dissipates tidal energy via friction and disperses salt.
- Dispersion caused by
 - Sheared flow
 - “Geometry dispersion”
 - Tidal pumping
 - *Tidal trapping*

Meters

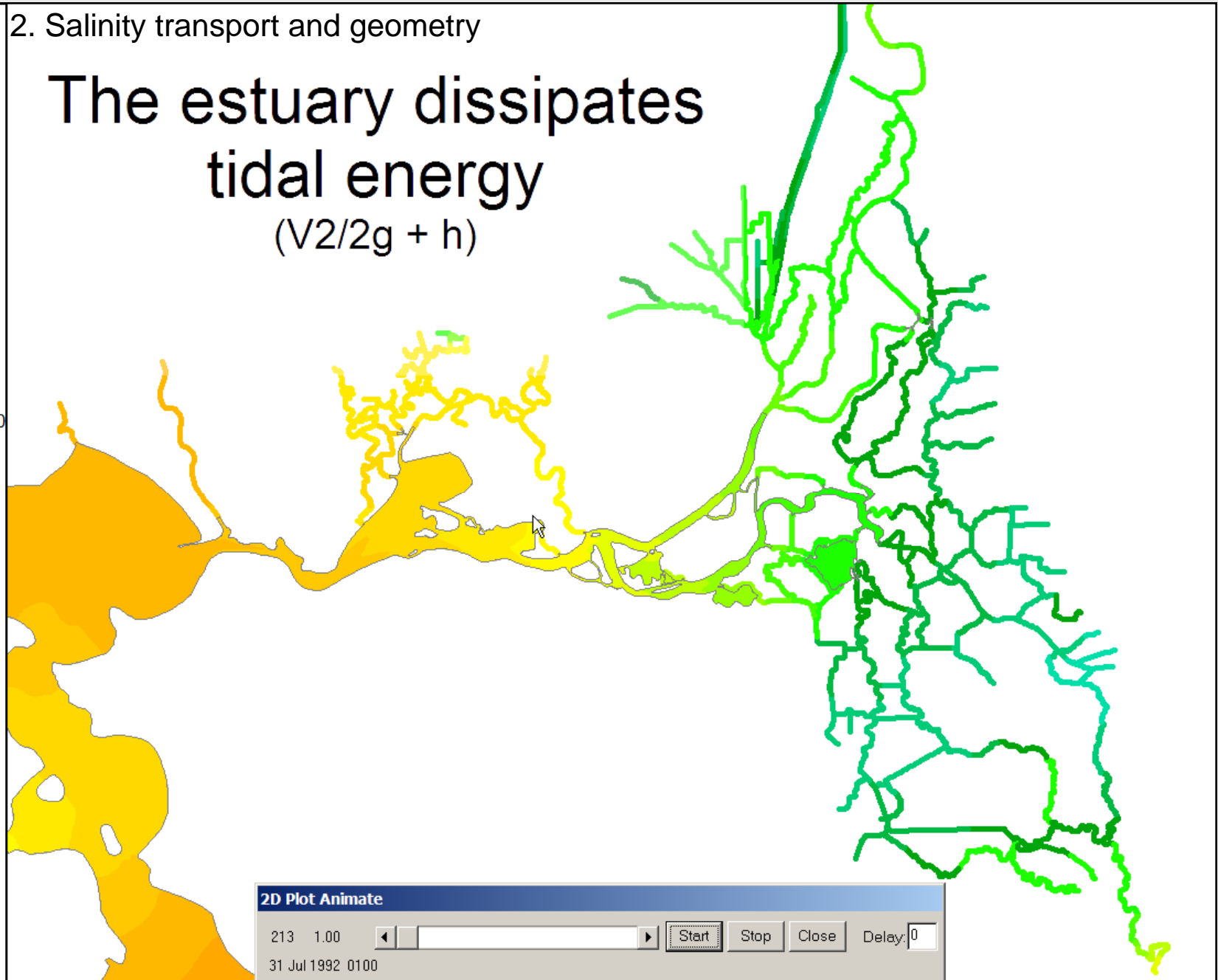
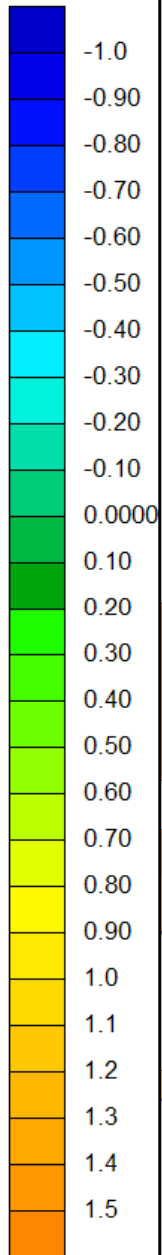
2. Salinity transport and geometry

The estuary dissipates
tidal energy
($V^2/2g + h$)



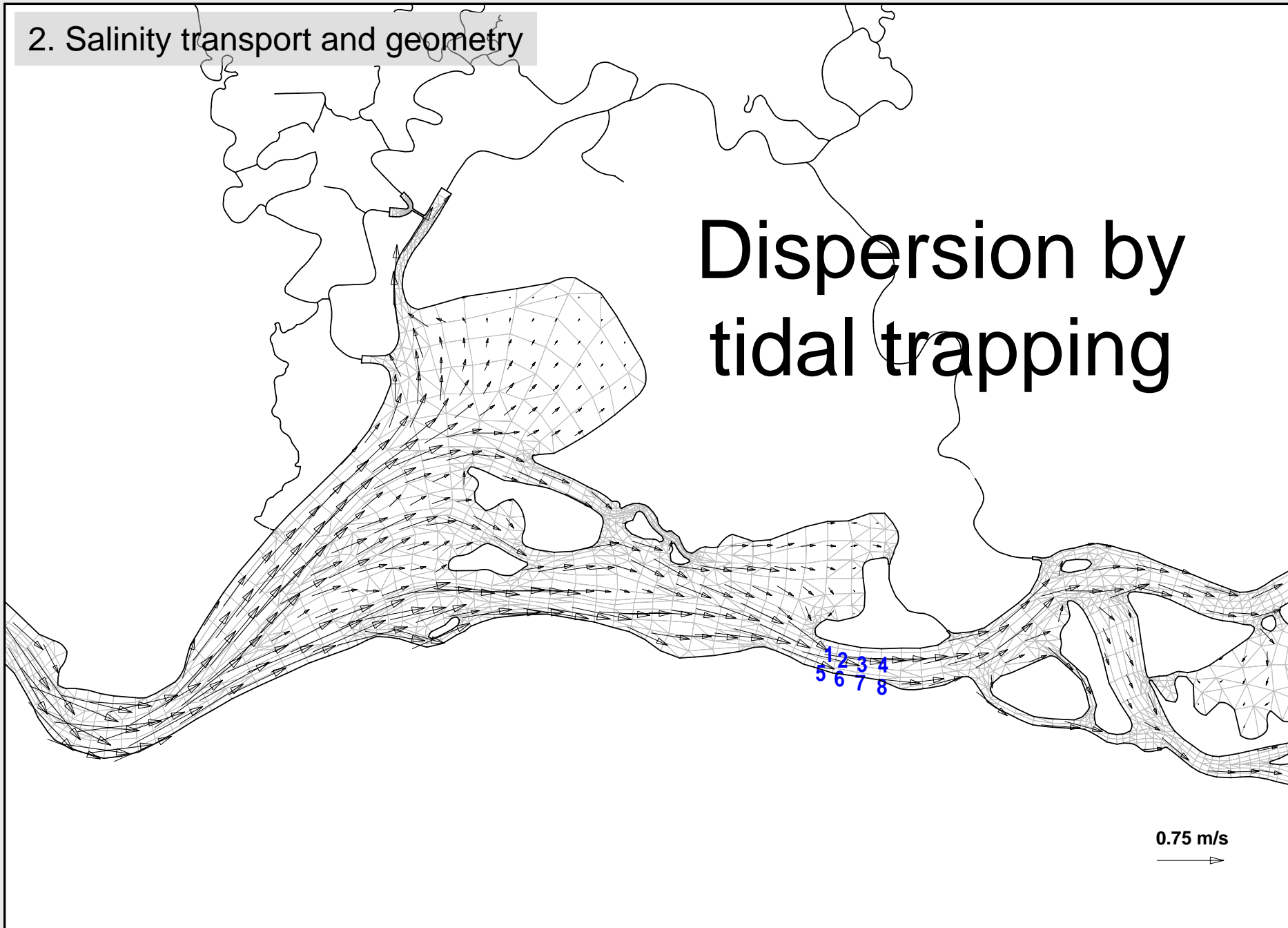
2. Salinity transport and geometry

The estuary dissipates
tidal energy
($V^2/2g + h$)



2. Salinity transport and geometry

Dispersion by tidal trapping



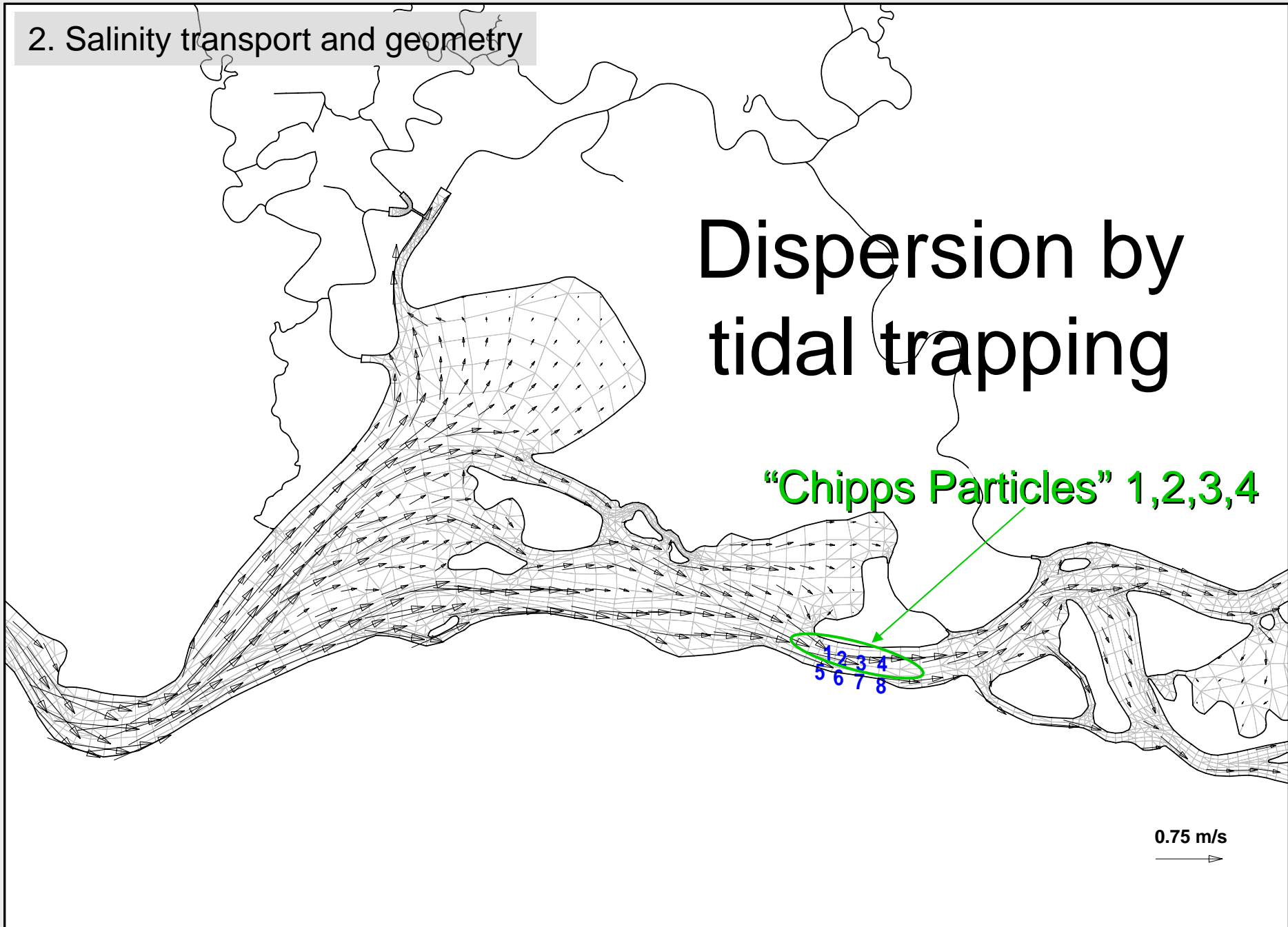
2. Salinity transport and geometry

Dispersion by tidal trapping

“Chipps Particles” 1,2,3,4

1 2 3 4
5 6 7 8

0.75 m/s



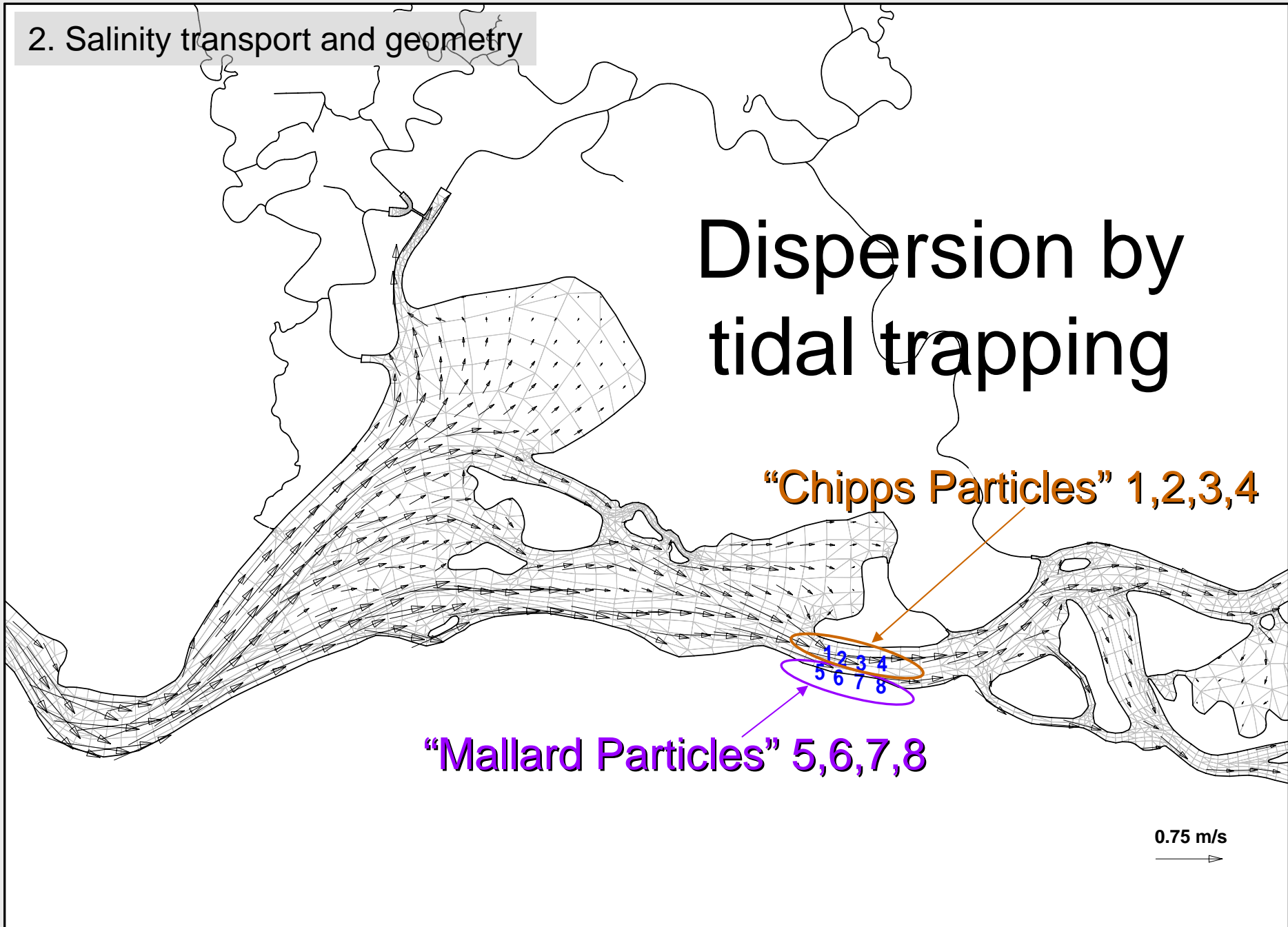
2. Salinity transport and geometry

Dispersion by tidal trapping

“Chipps Particles” 1,2,3,4

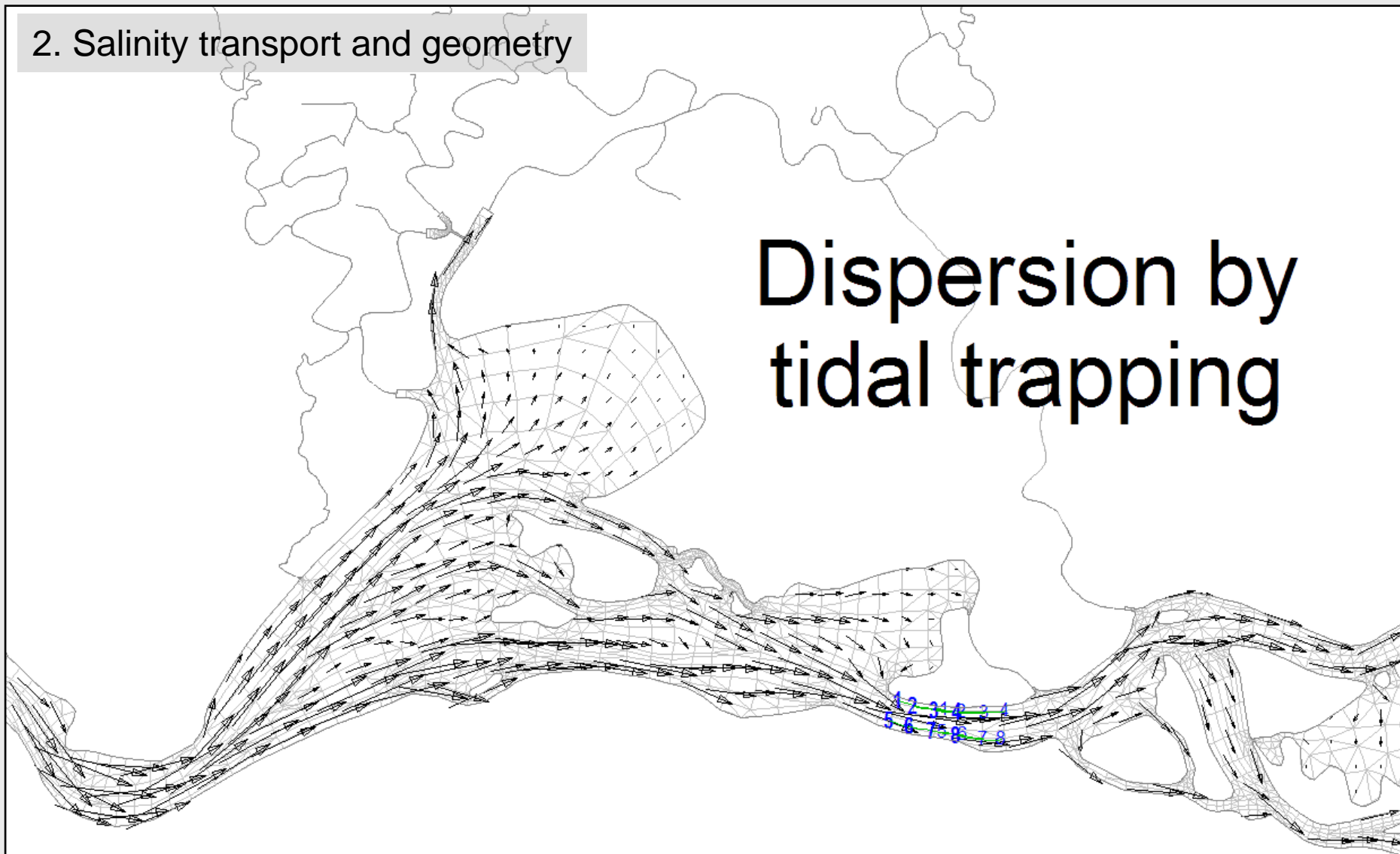
“Mallard Particles” 5,6,7,8

0.75 m/s



2. Salinity transport and geometry

Dispersion by tidal trapping



2D Plot Animate

213 0.50

31 Jul 1992 0030

Start

Stop

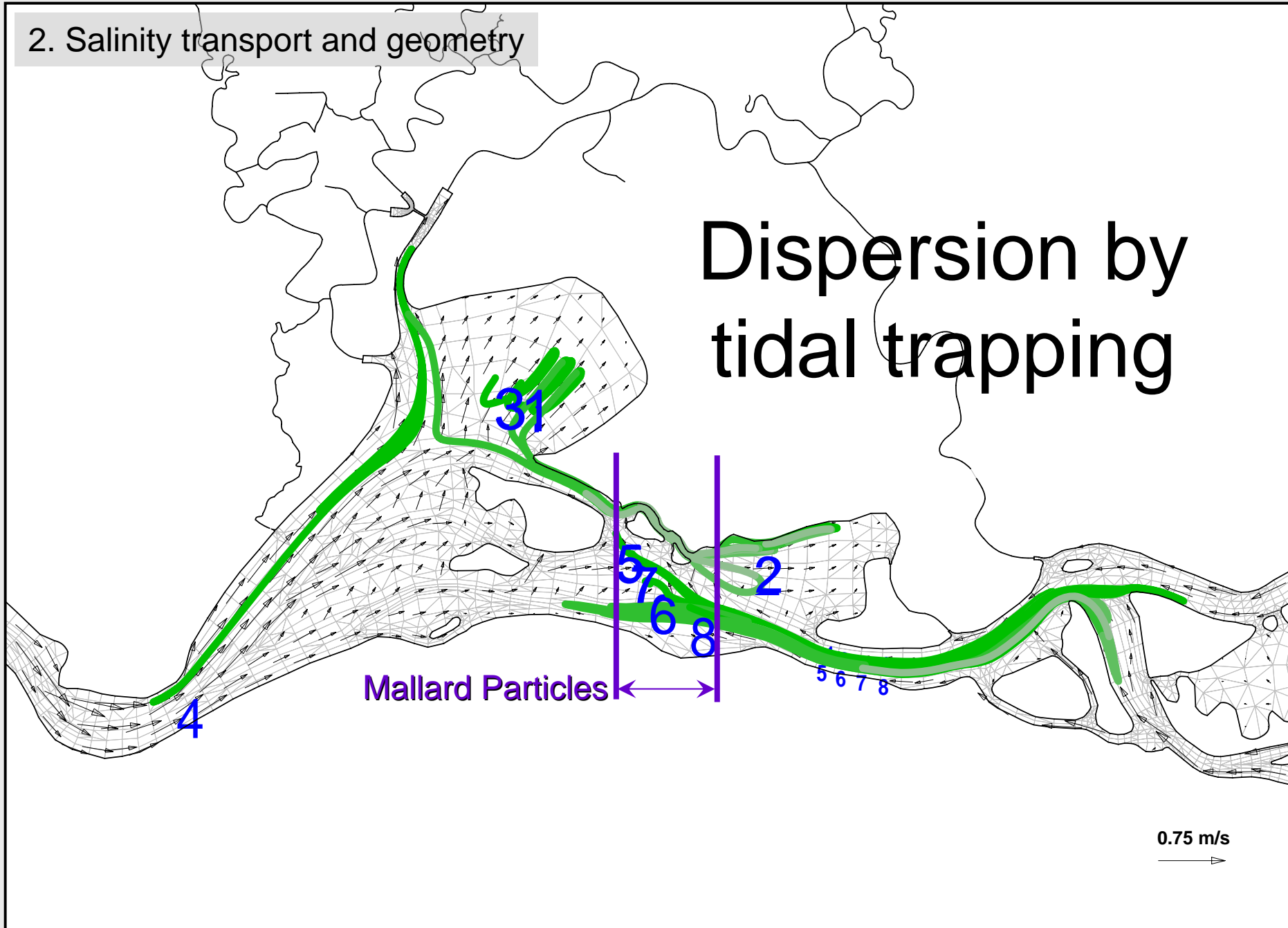
Close

Delay: 0

m/s

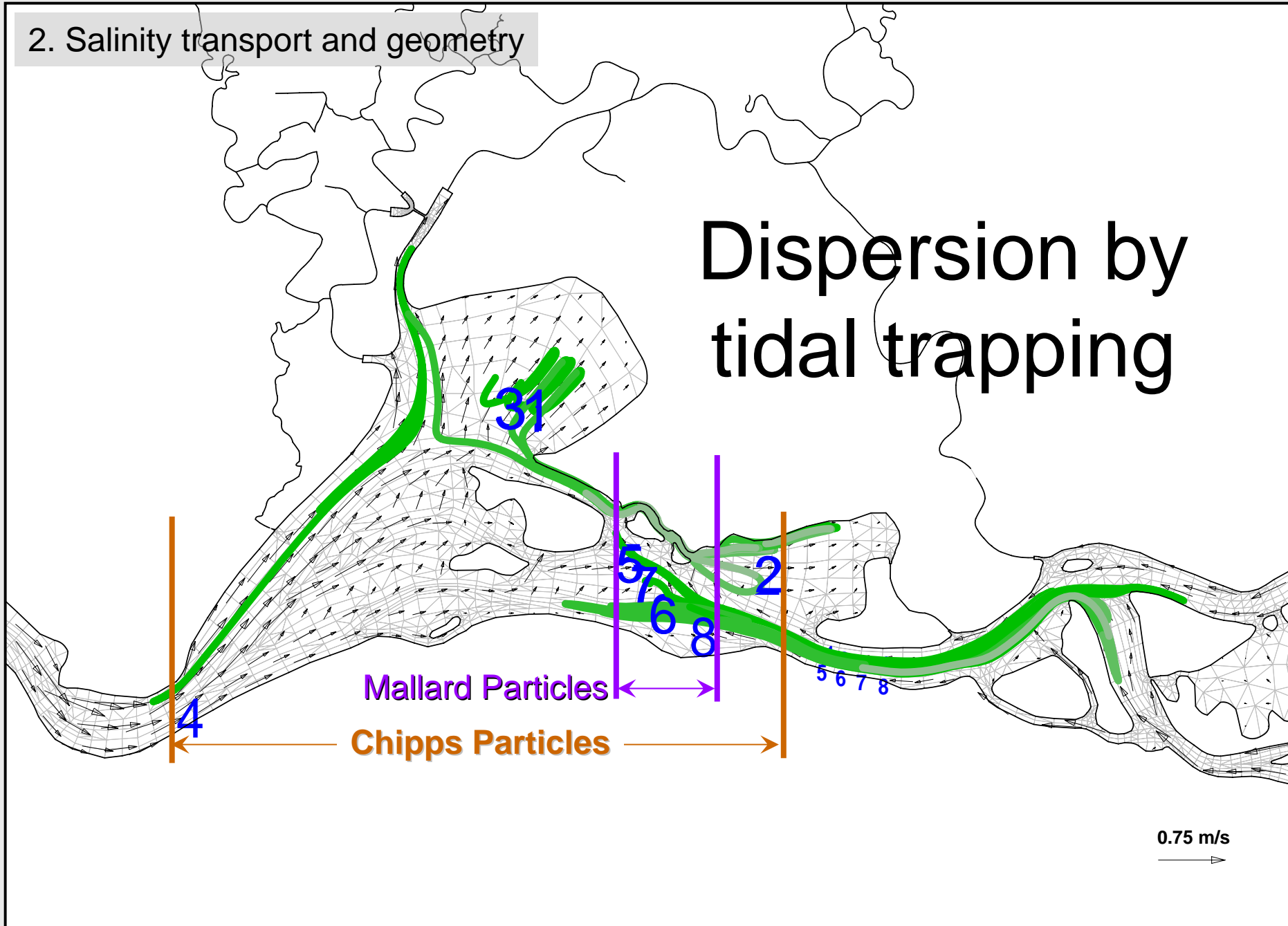
2. Salinity transport and geometry

Dispersion by tidal trapping



2. Salinity transport and geometry

Dispersion by tidal trapping



3. Natural vs. human influence on geometry and salinity

“Natural” salinity trend drivers

- Climate/Ocean conditions
 - (ENSO 3-5 yr, PDO 20-30 yr)
- Coastal upwelling
- Climate change and runoff to SF Estuary
- Sea level rise ~1-2 mm/year
- Sediment transport- bathymetry change:
 - Hydraulic mining sediment transport

“Natural” salinity trend drivers

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Human influenced salinity trend drivers

- Delta channel cuts
- Ship channels
- Channel meander cutoffs
- Subsided, then flooded islands

Human influenced salinity trend drivers

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Suisun Bay bathymetry

- Eroded 106 cm since 1922
- > 100 million cubic meters
- How does deepening Suisun Bay affect estuary salinity?

3. Natural and human influence...

- We raised elevation of Suisun Bay by 0.75 meters (1922 bathymetry)

umhos/cm

-20.0

-18.3

-16.7

-15.0

-13.3

-11.7

-10.0

-8.3

-6.7

-5.0

-3.3

-1.7

-0.0000

1.7

3.3

5.0

6.7

8.3

10

11.7

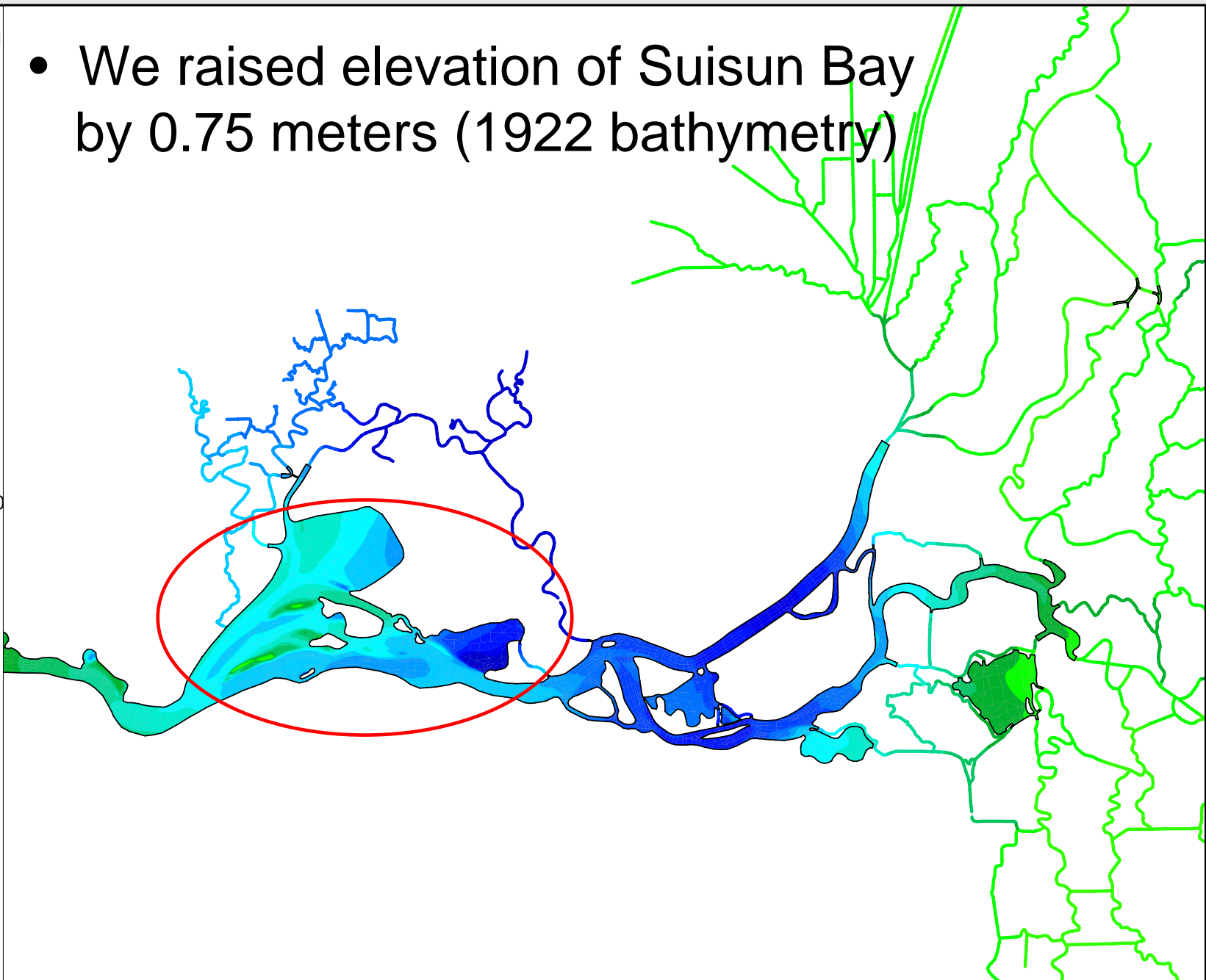
13.3

15.0

16.7

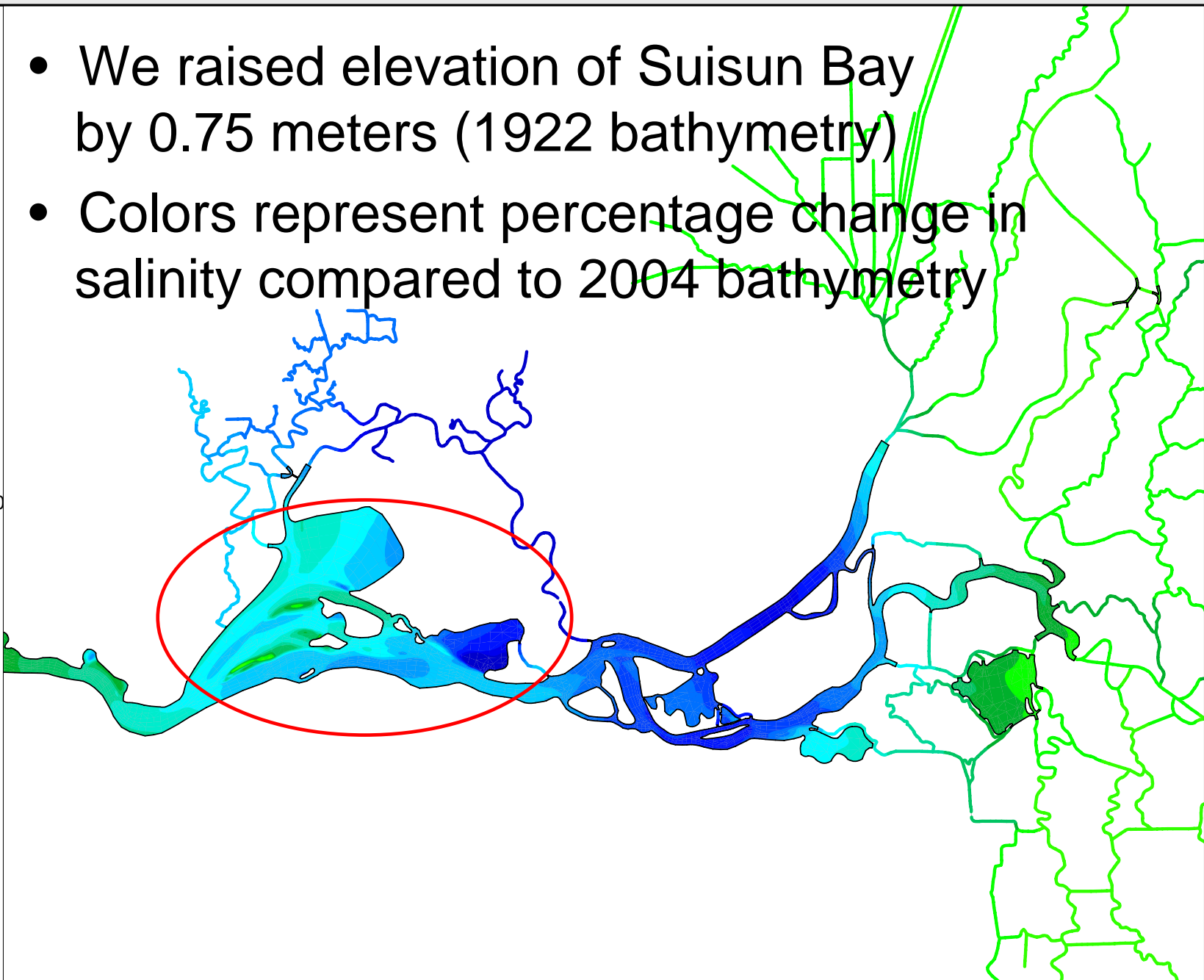
18.3

20.0

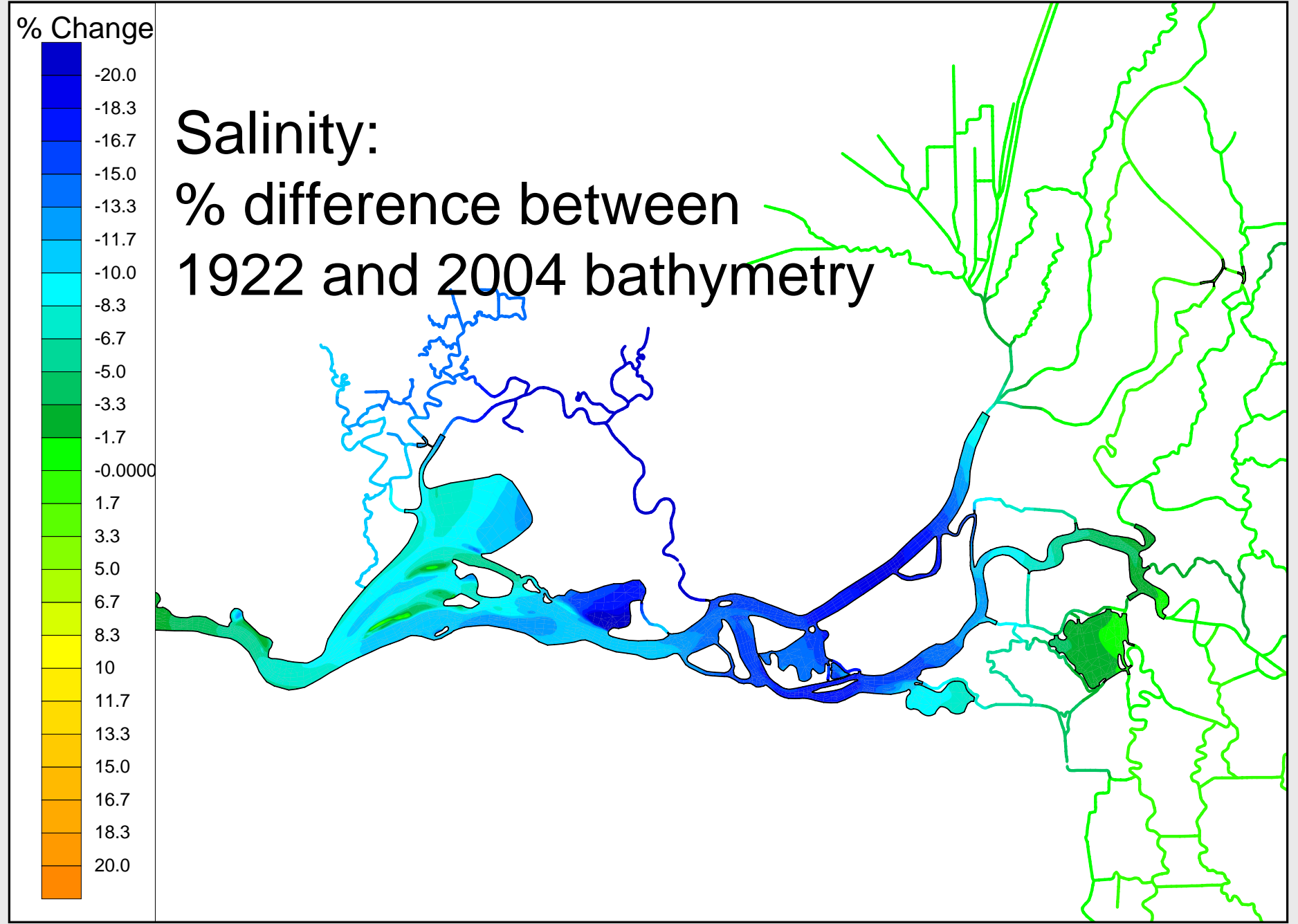


3. Natural and human influence...

- We raised elevation of Suisun Bay by 0.75 meters (1922 bathymetry)
- Colors represent percentage change in salinity compared to 2004 bathymetry

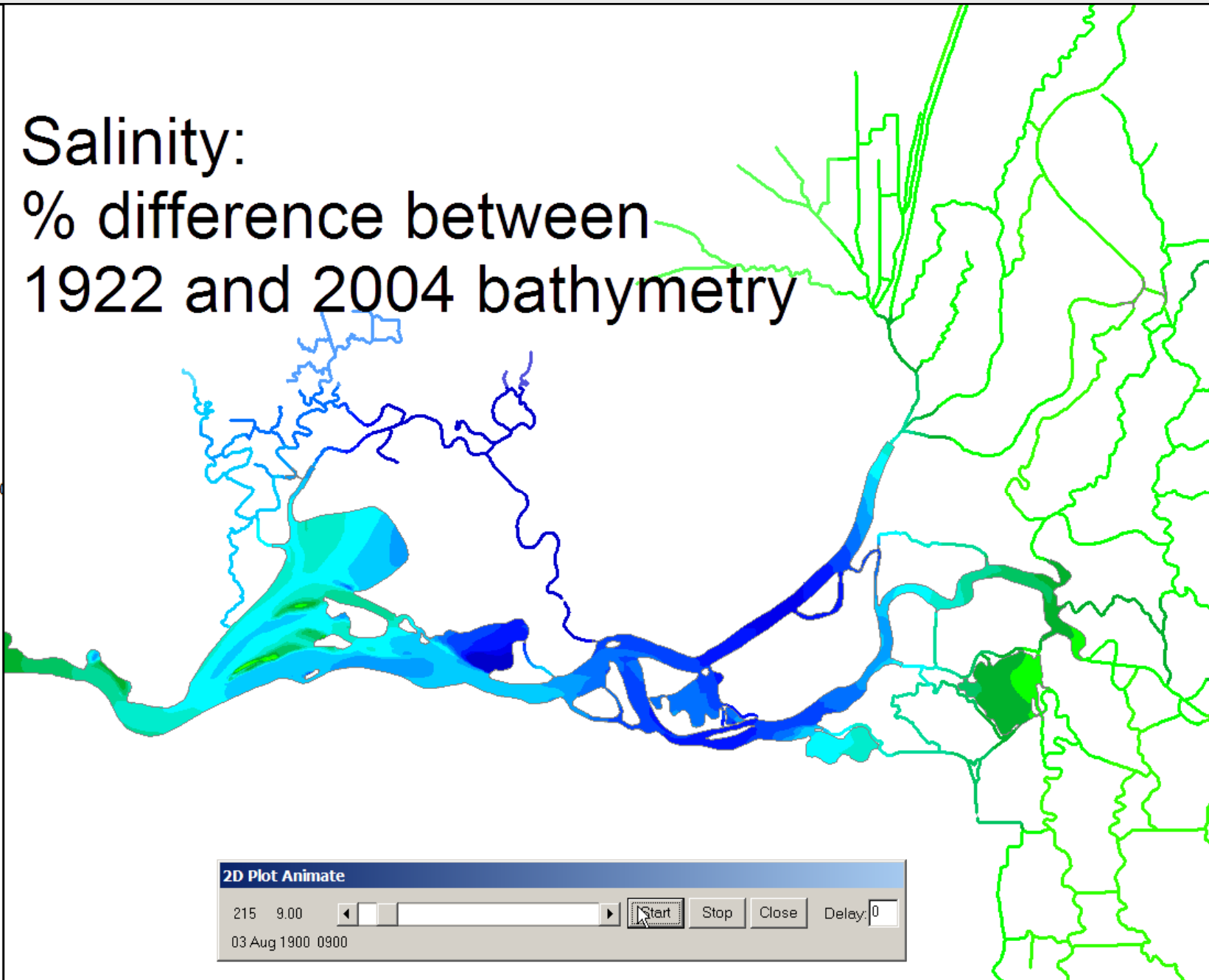
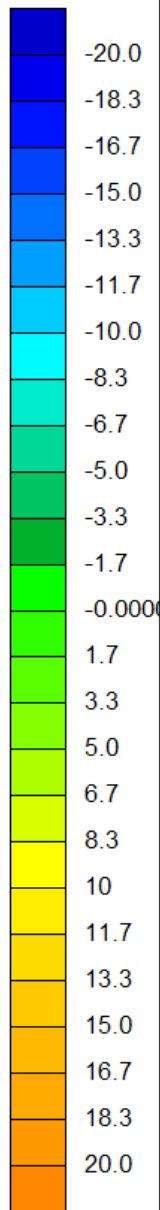


3. Natural and human influence...



3. Natural and human influence...

Salinity:
% difference between
1922 and 2004 bathymetry



Mechanisms

- Tidal datum



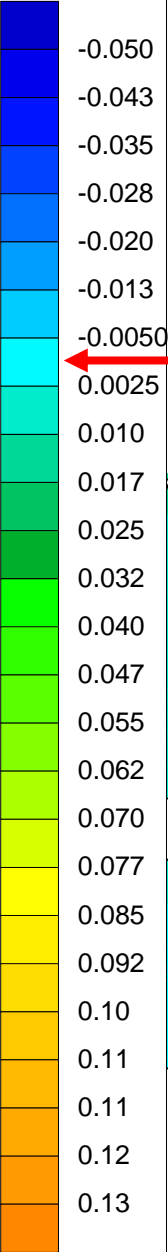
- Tidal excursion
- Salt flux

3. Natural and human influence...

Meters

Difference between 1922 and 2004 Suisun Bay bathymetry

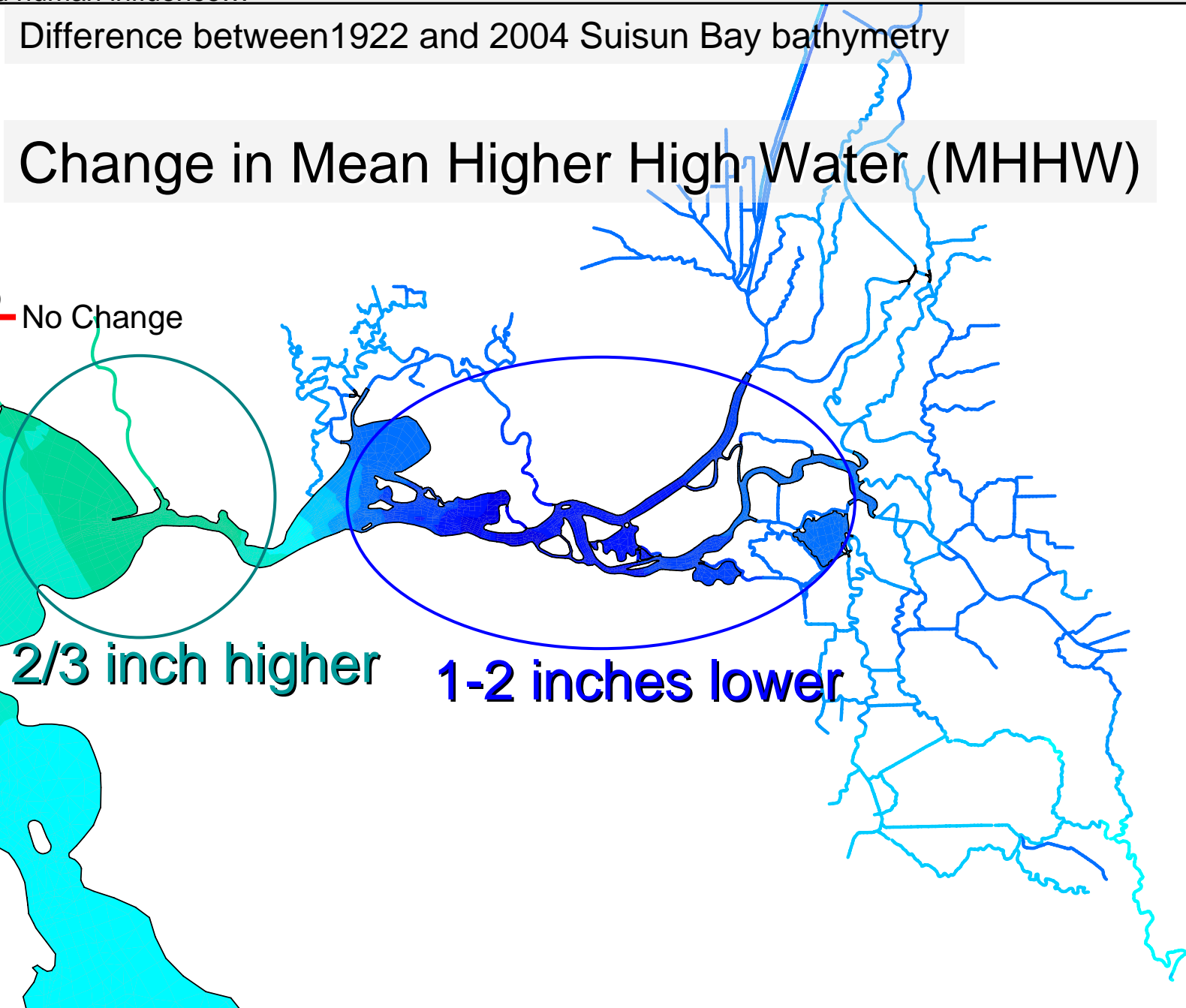
Change in Mean Higher High Water (MHHW)

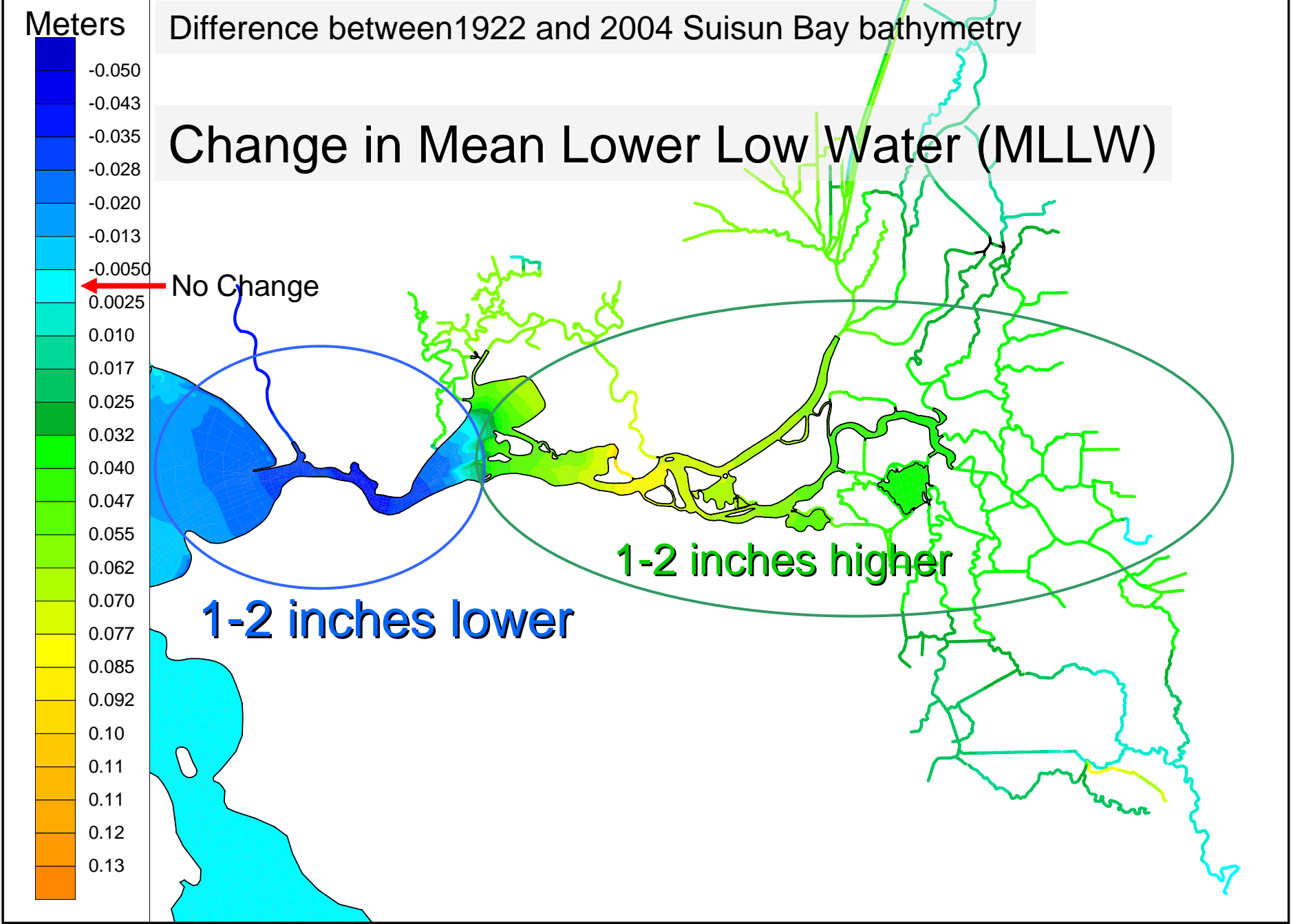


No Change

2/3 inch higher

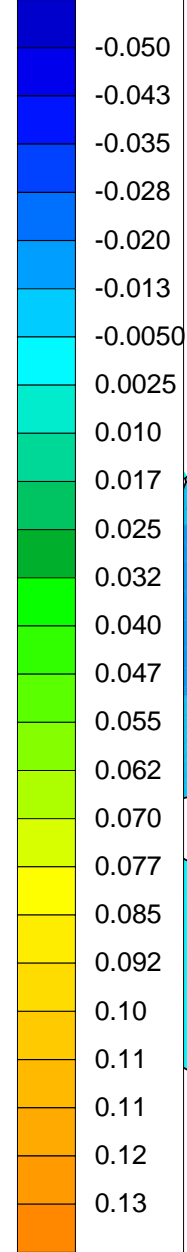
1-2 inches lower





3. Natural and human influence...

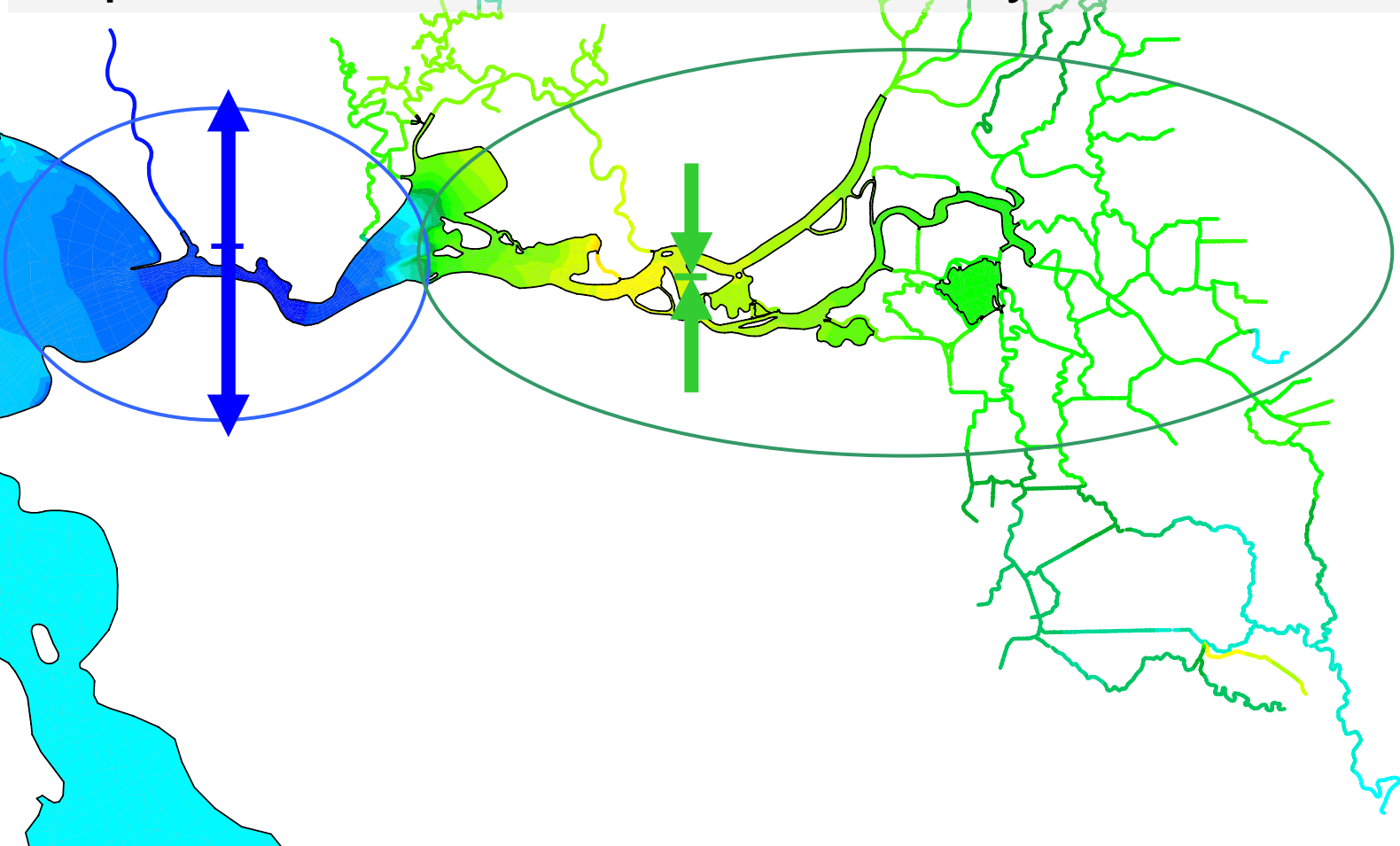
Meters

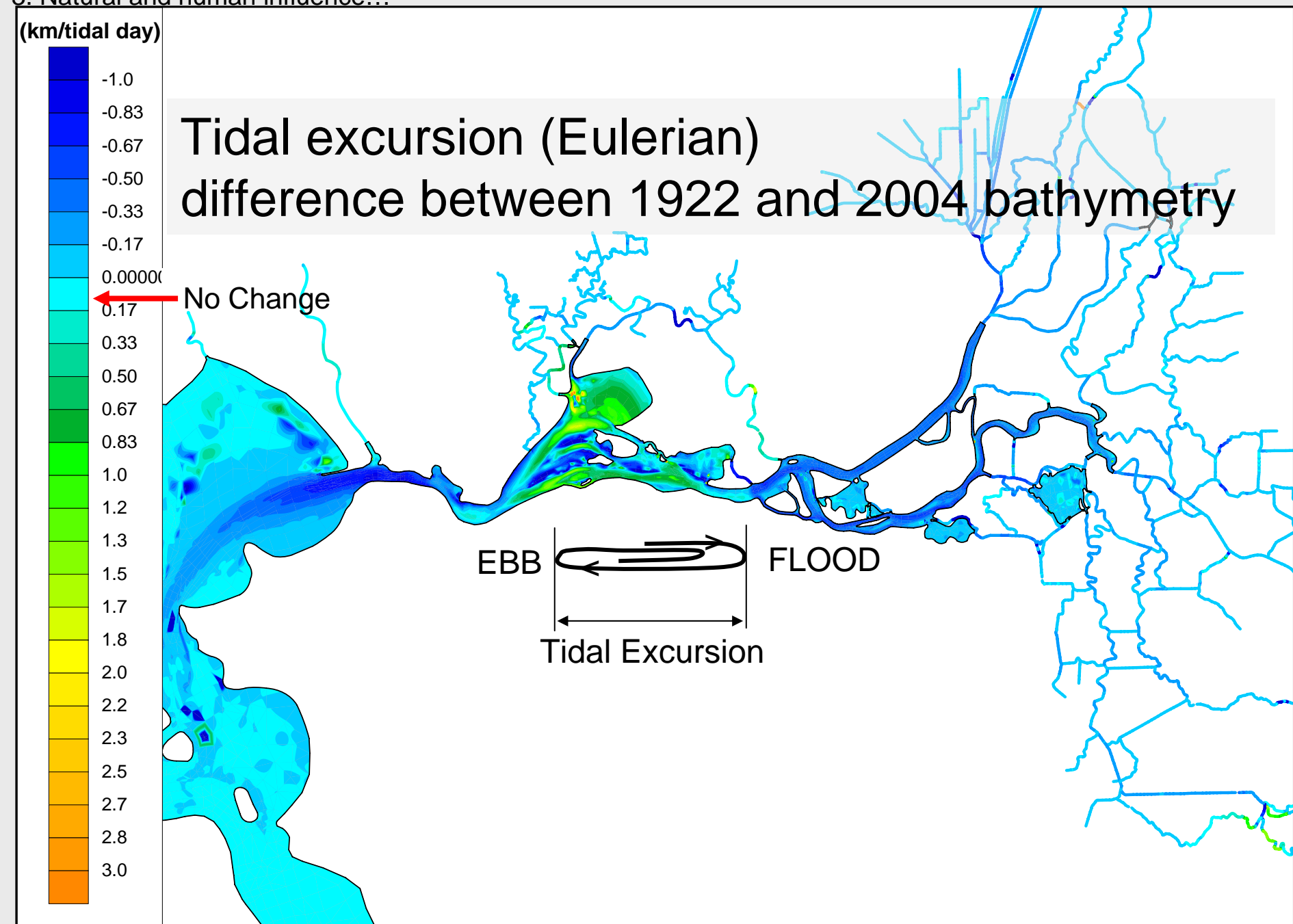


Difference between 1922 and 2004 Suisun Bay bathymetry

So in 1922, the tidal range was

- up to 3 inches **greater** in SP Bay/Carquinez St.
- up to 4 inches **less** in Suisun Bay/Delta

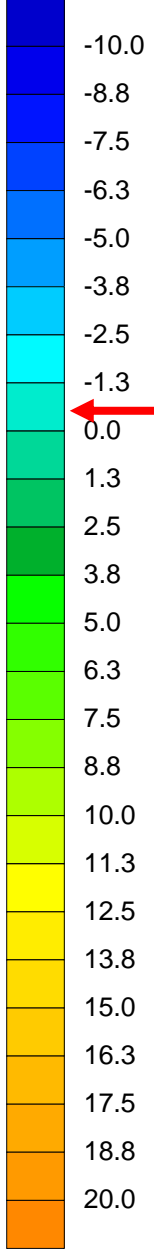




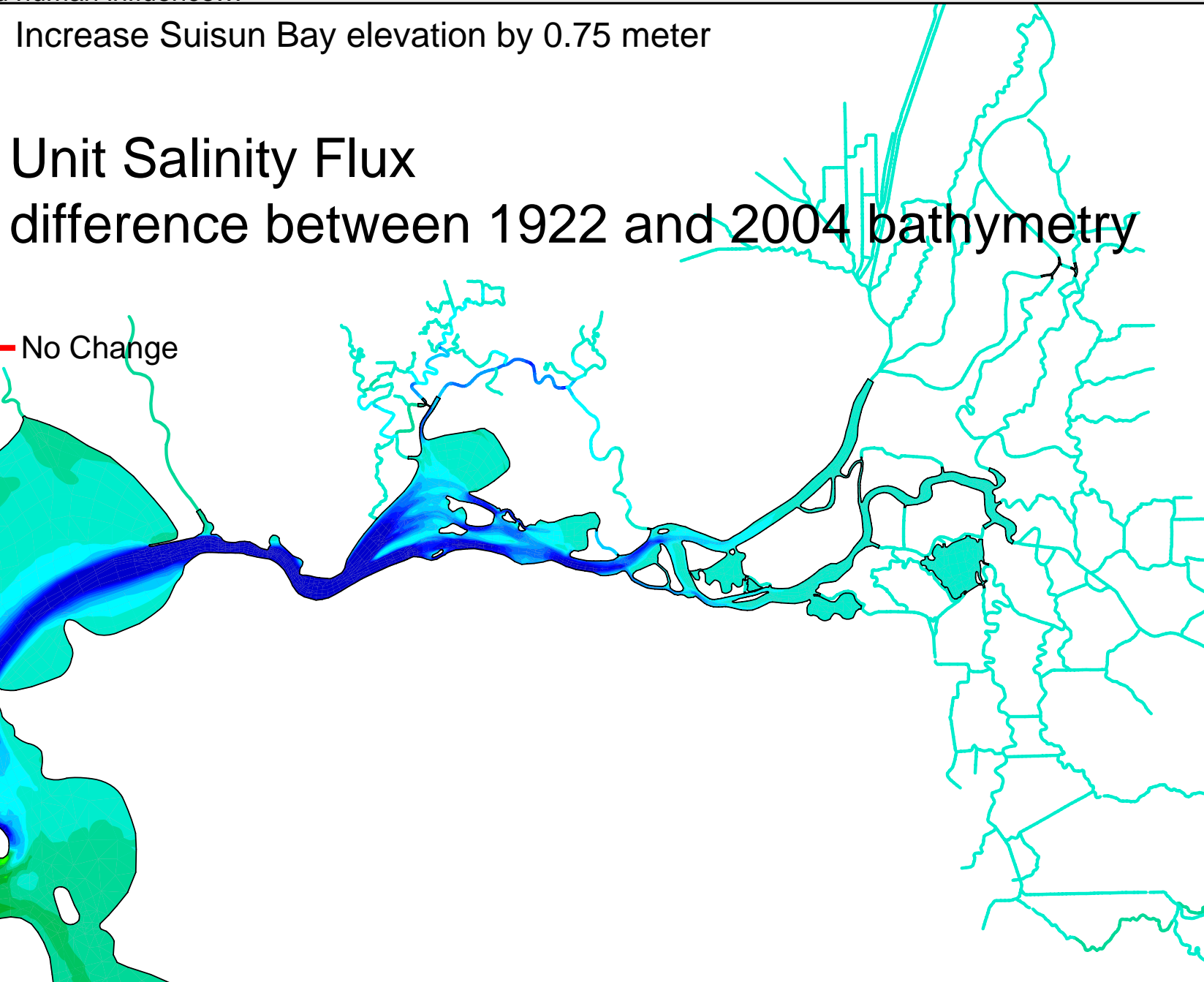
kg/m*s

Increase Suisun Bay elevation by 0.75 meter

Unit Salinity Flux difference between 1922 and 2004 bathymetry

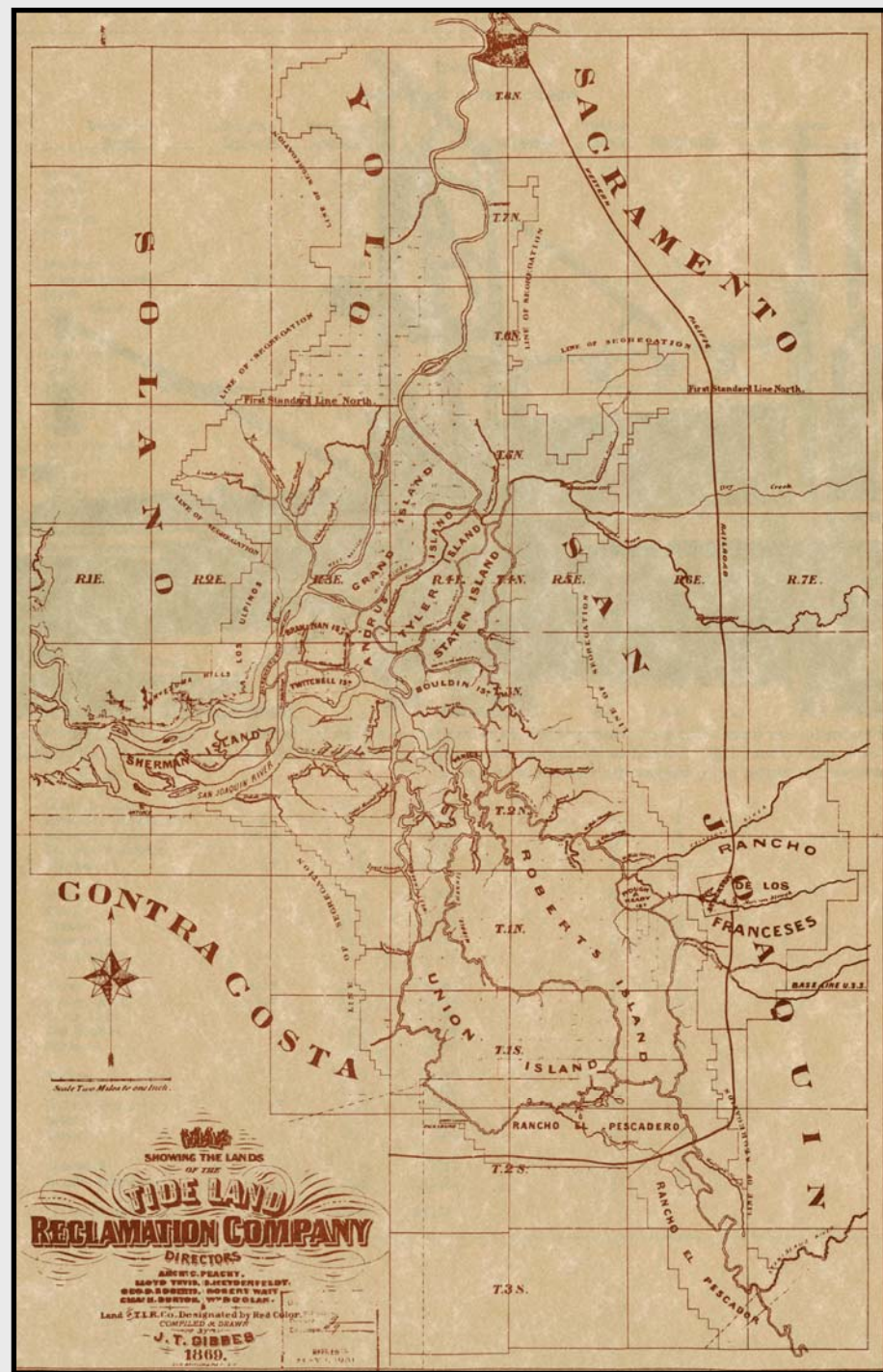


No Change



Influence of Delta channel cuts on Suisun and Delta salinity

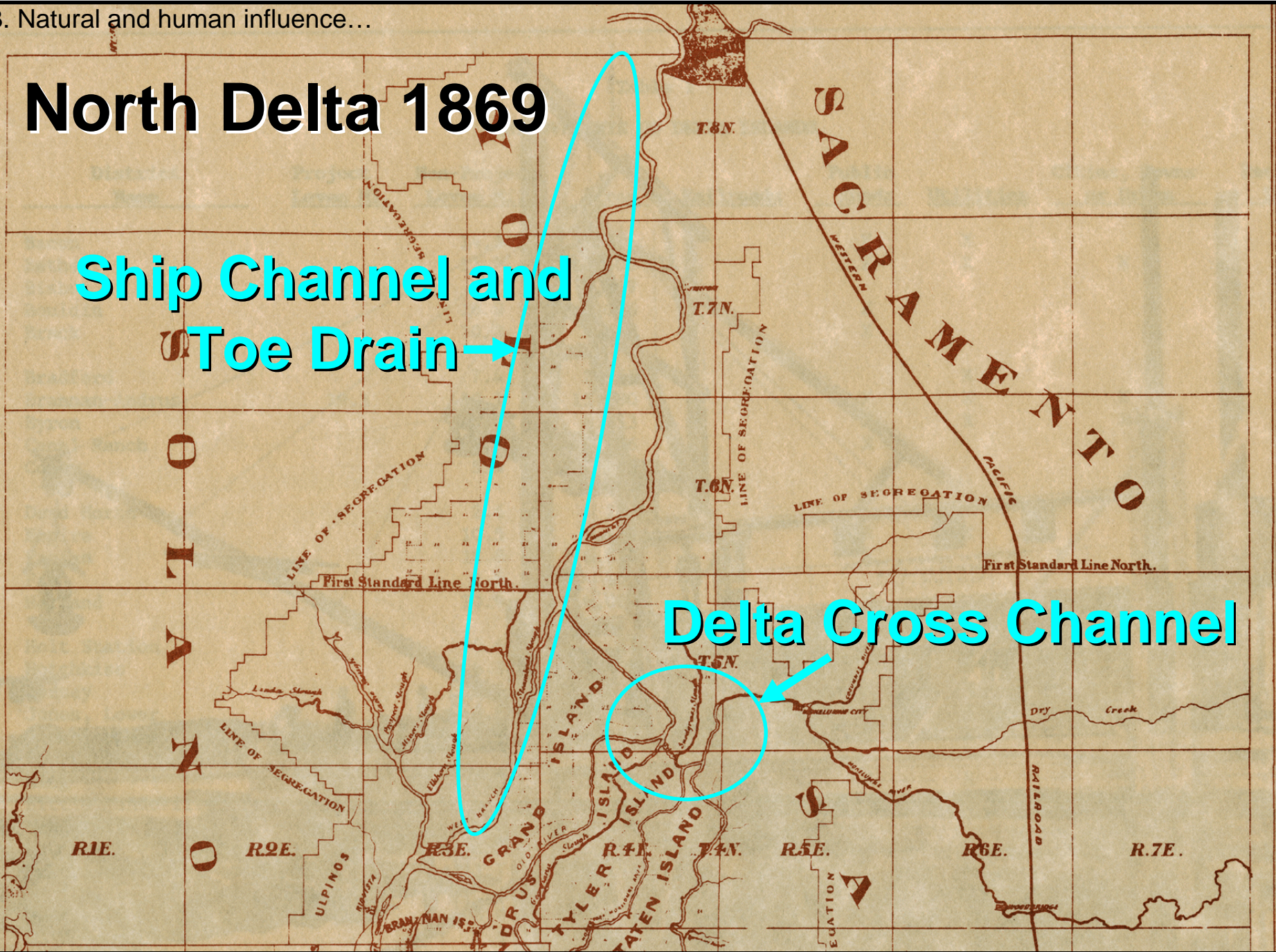
Delta Map 1869



North Delta 1869

Ship Channel and
Toe Drain →

Delta Cross Channel



3. Natural and human influence...

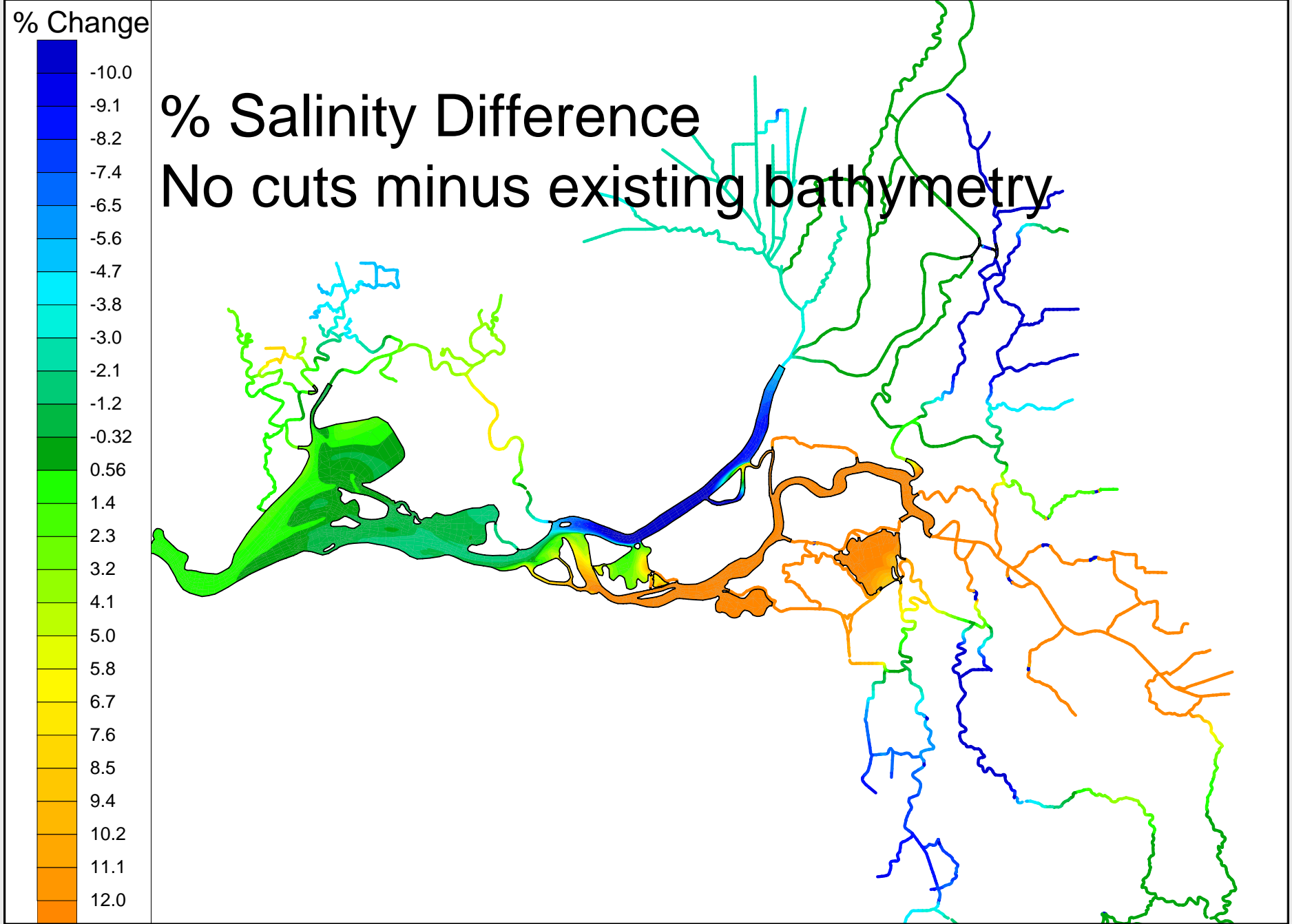
South Delta 1869

A historical map of the South Delta region in 1869, showing the San Joaquin River and various islands and ranches. The map is overlaid with a grid of townships and ranges. Several features are highlighted with red circles and labeled in red text:

- King Is. Cuts
- Columbia Cut
- Turner Cut
- Empire Cut
- Grant Line Canal
- Bacon and Woodward Cuts
- Victoria Canal

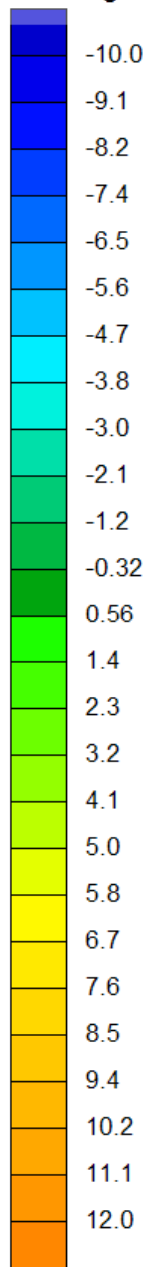
The map also includes labels for Sherman Island, Twitchell Is., Bouldin Is., and various ranches such as Rancho de los Franceses and Rancho Pescadero. A compass rose and a scale bar are visible in the bottom left corner.

3. Natural and human influence...

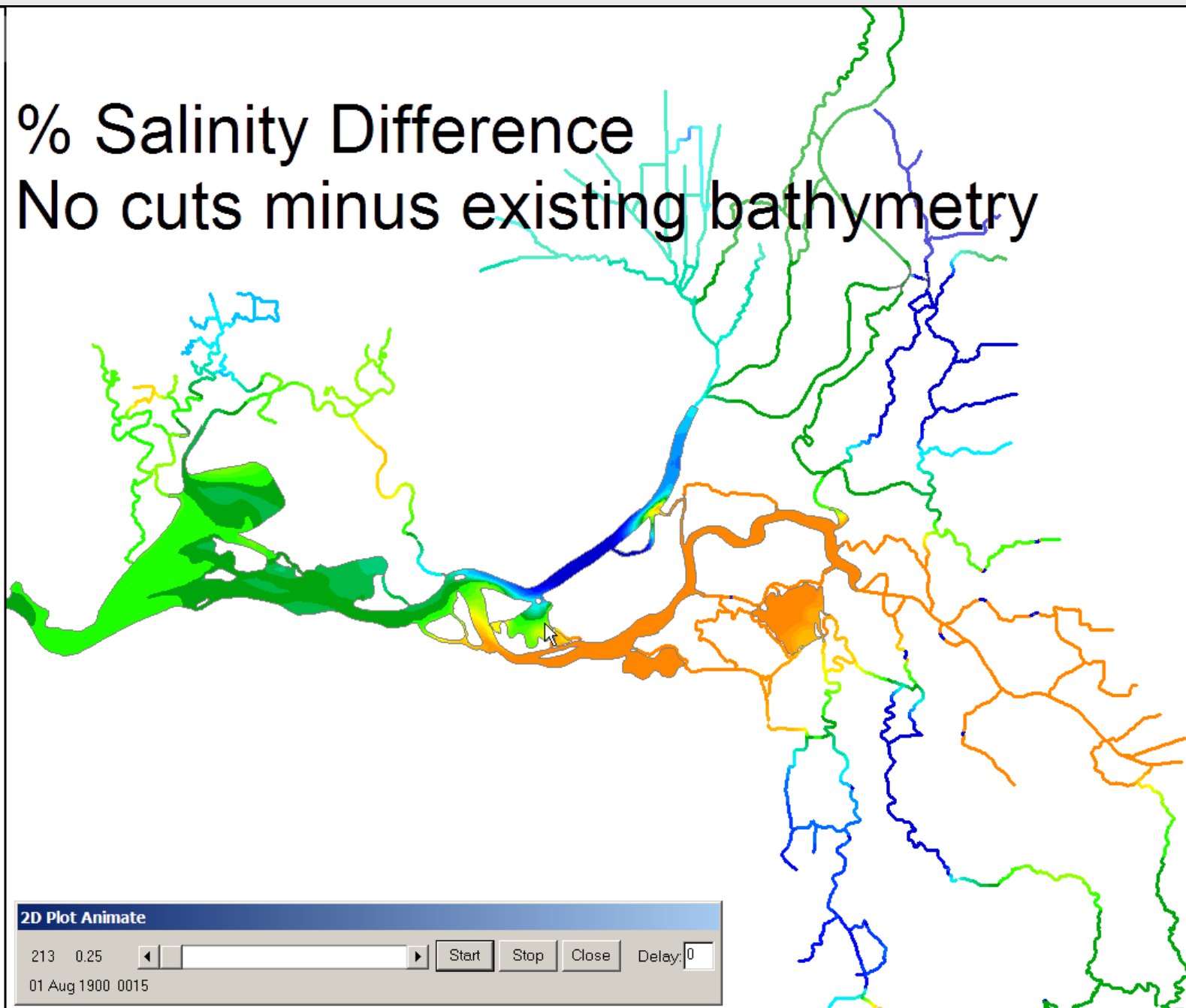


3. Natural and human influence...

% Change



% Salinity Difference
No cuts minus existing bathymetry



2D Plot Animate

213 0.25

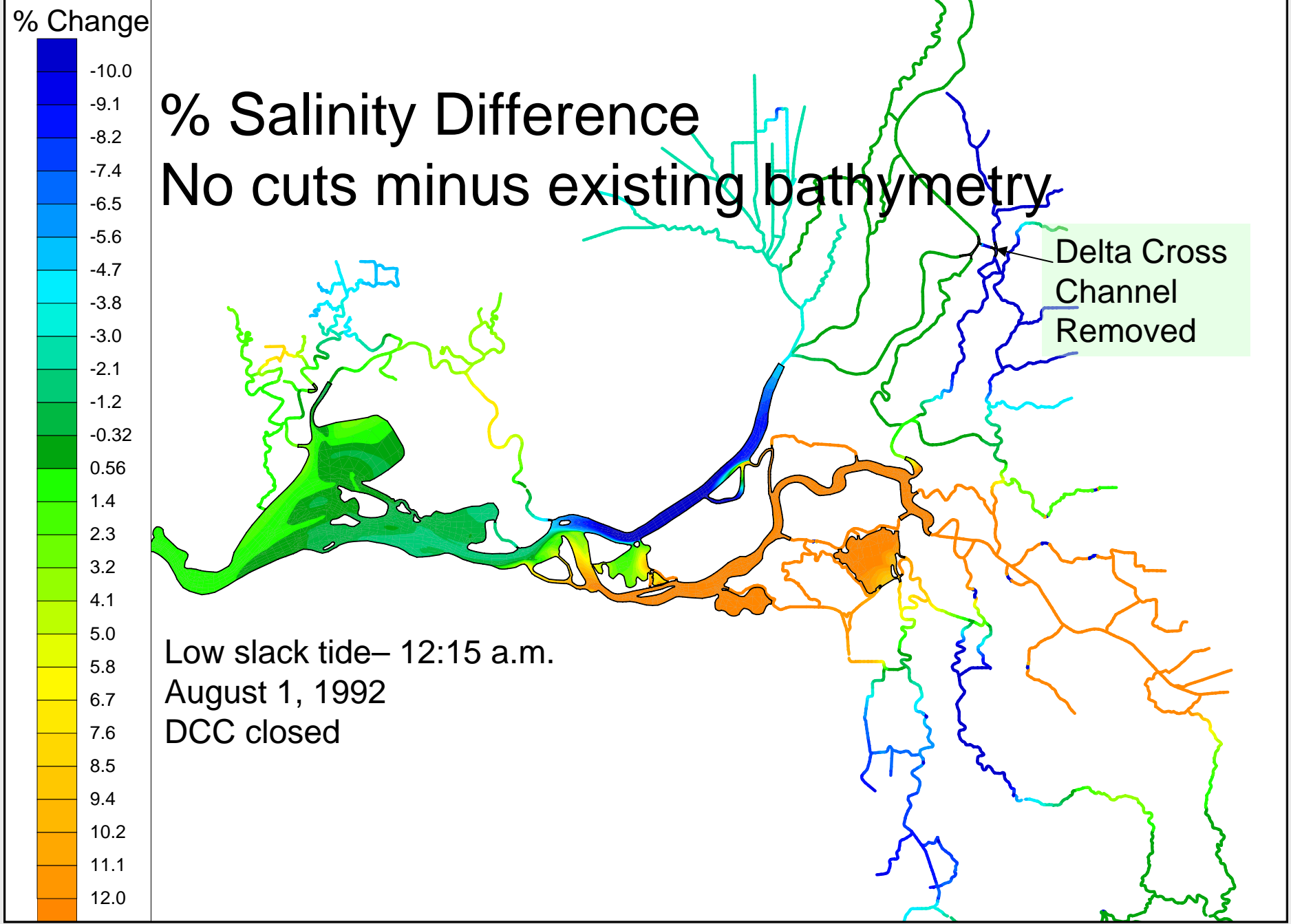
01 Aug 1900 0015

Start

Stop

Close

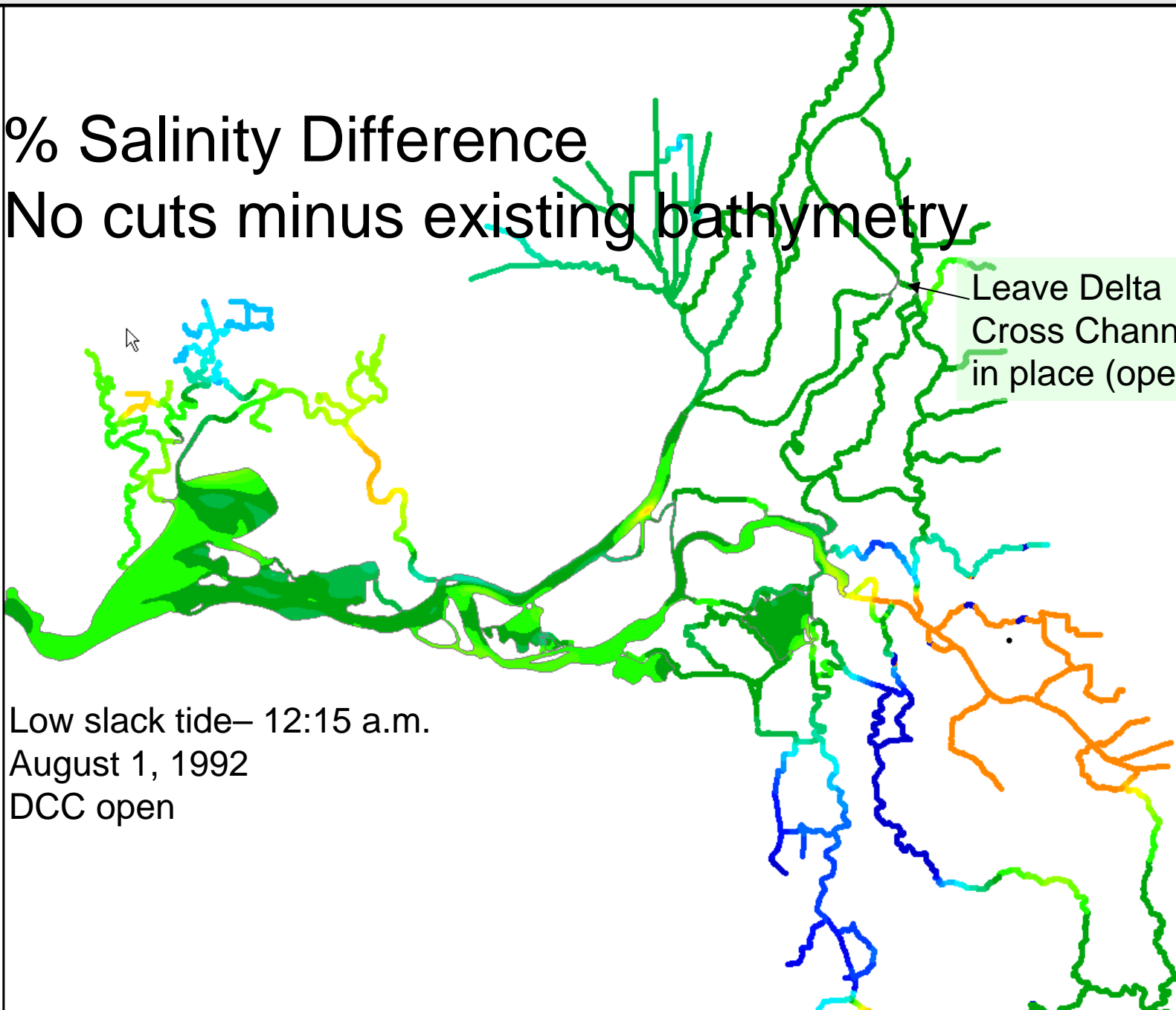
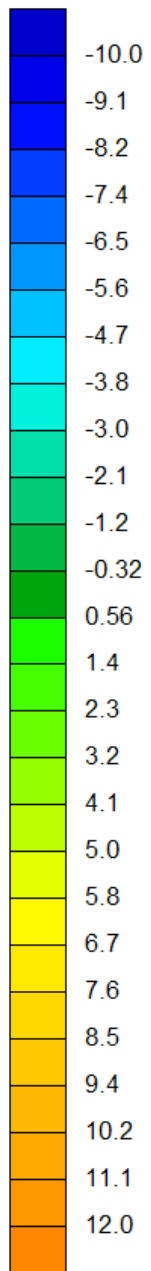
Delay: 0



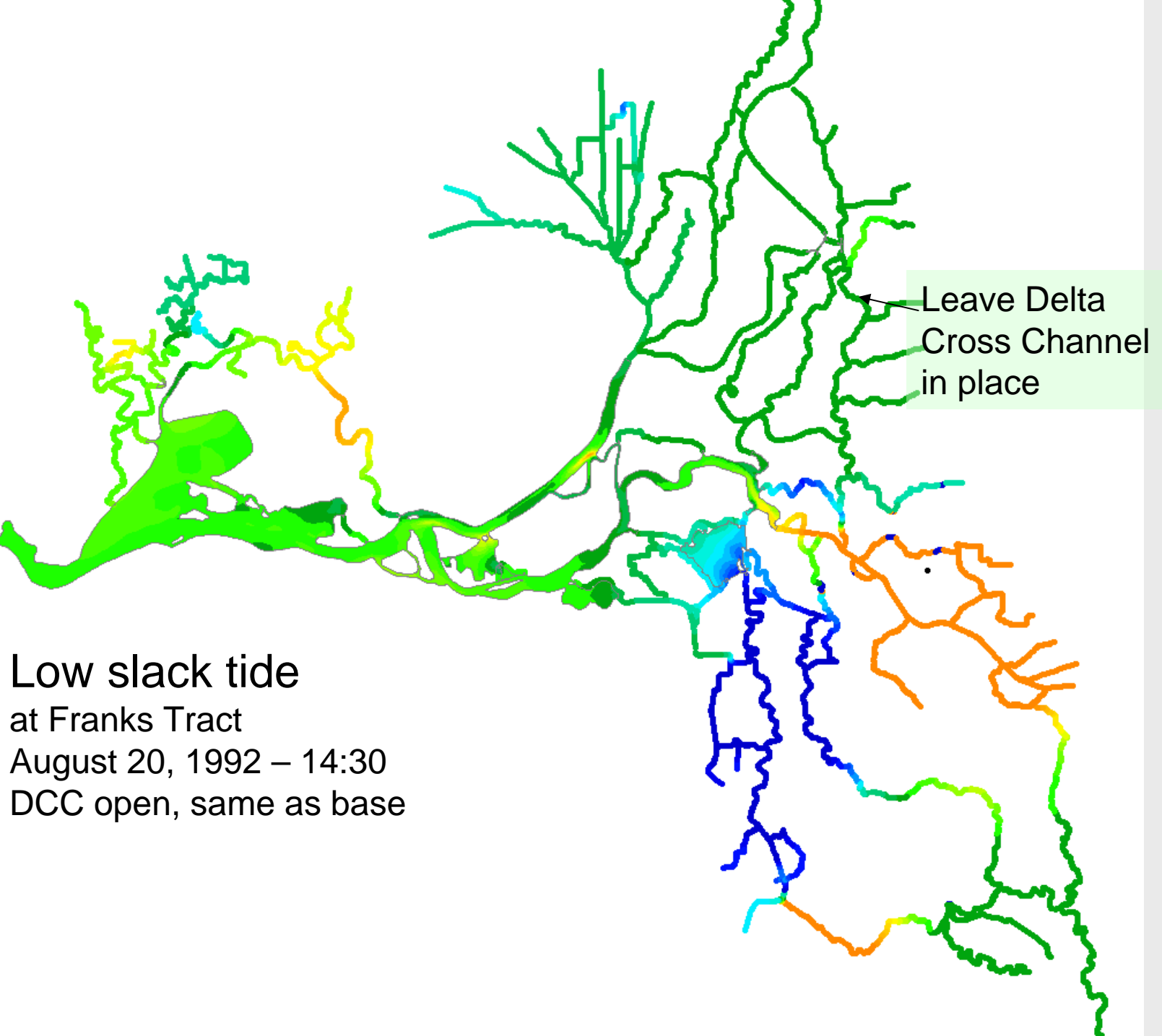
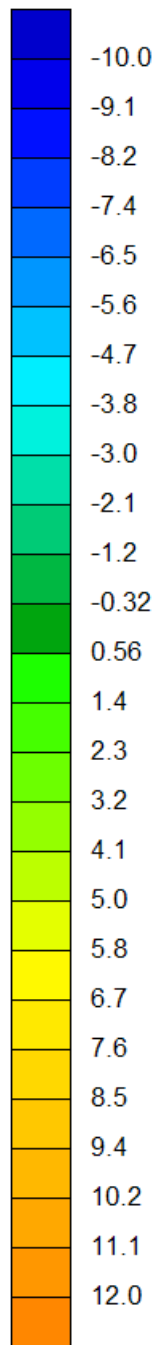
% Salinity Difference No cuts minus existing bathymetry

Leave Delta
Cross Channel
in place (open)

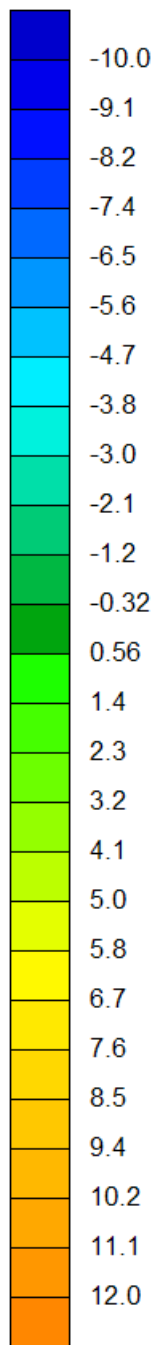
Low slack tide— 12:15 a.m.
August 1, 1992
DCC open



4

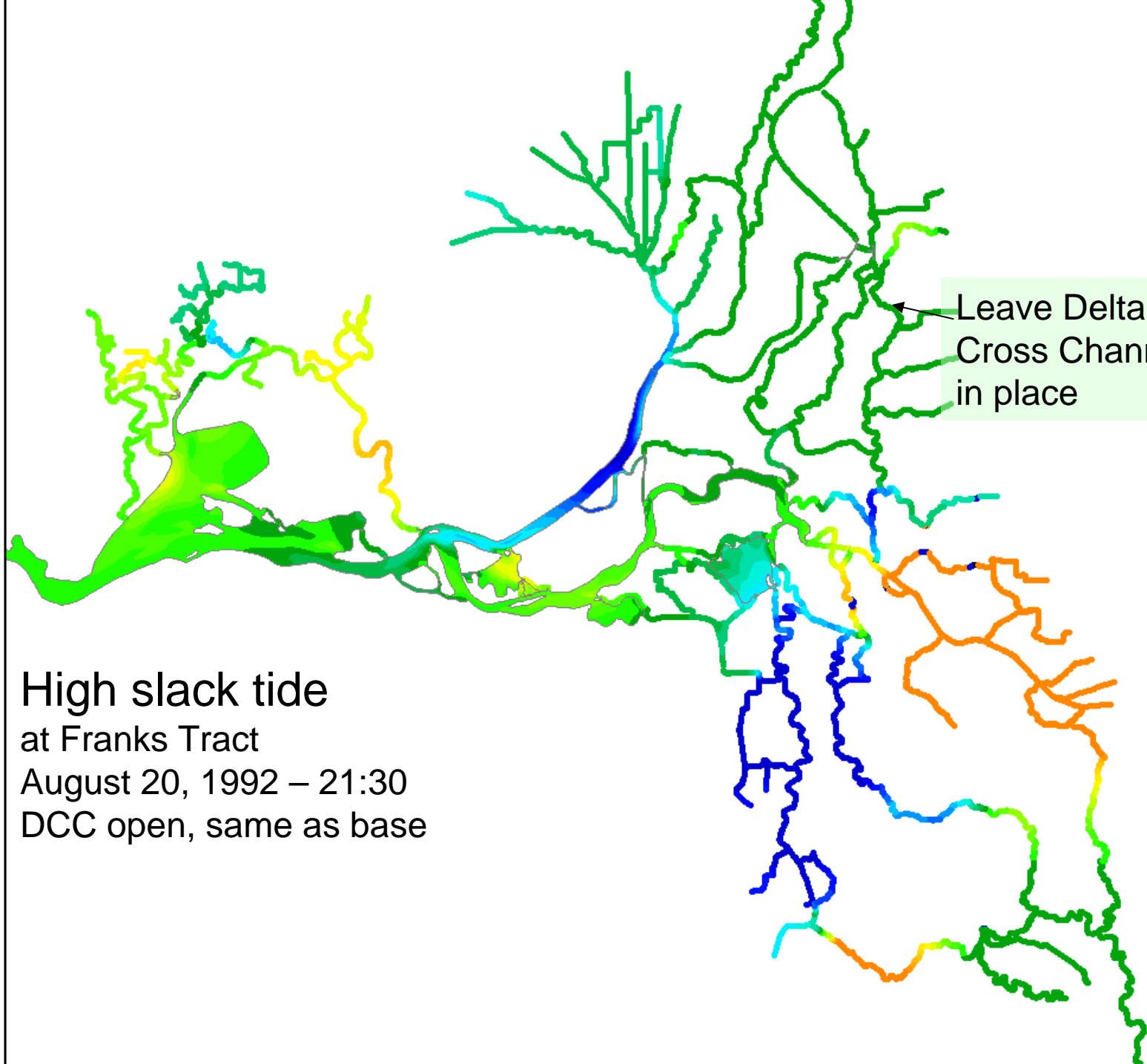


Low slack tide
at Franks Tract
August 20, 1992 – 14:30
DCC open, same as base



High slack tide
at Franks Tract
August 20, 1992 – 21:30
DCC open, same as base

Leave Delta
Cross Channel
in place

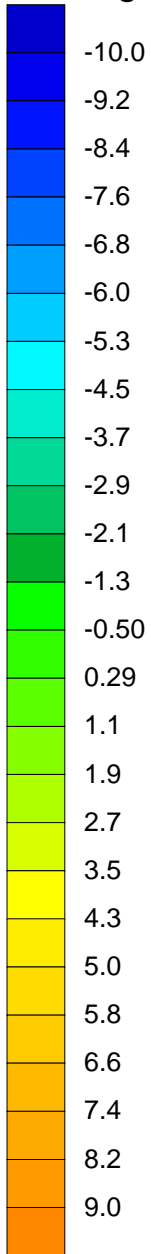


Influence of lower sea-level on Suisun and Delta salinity

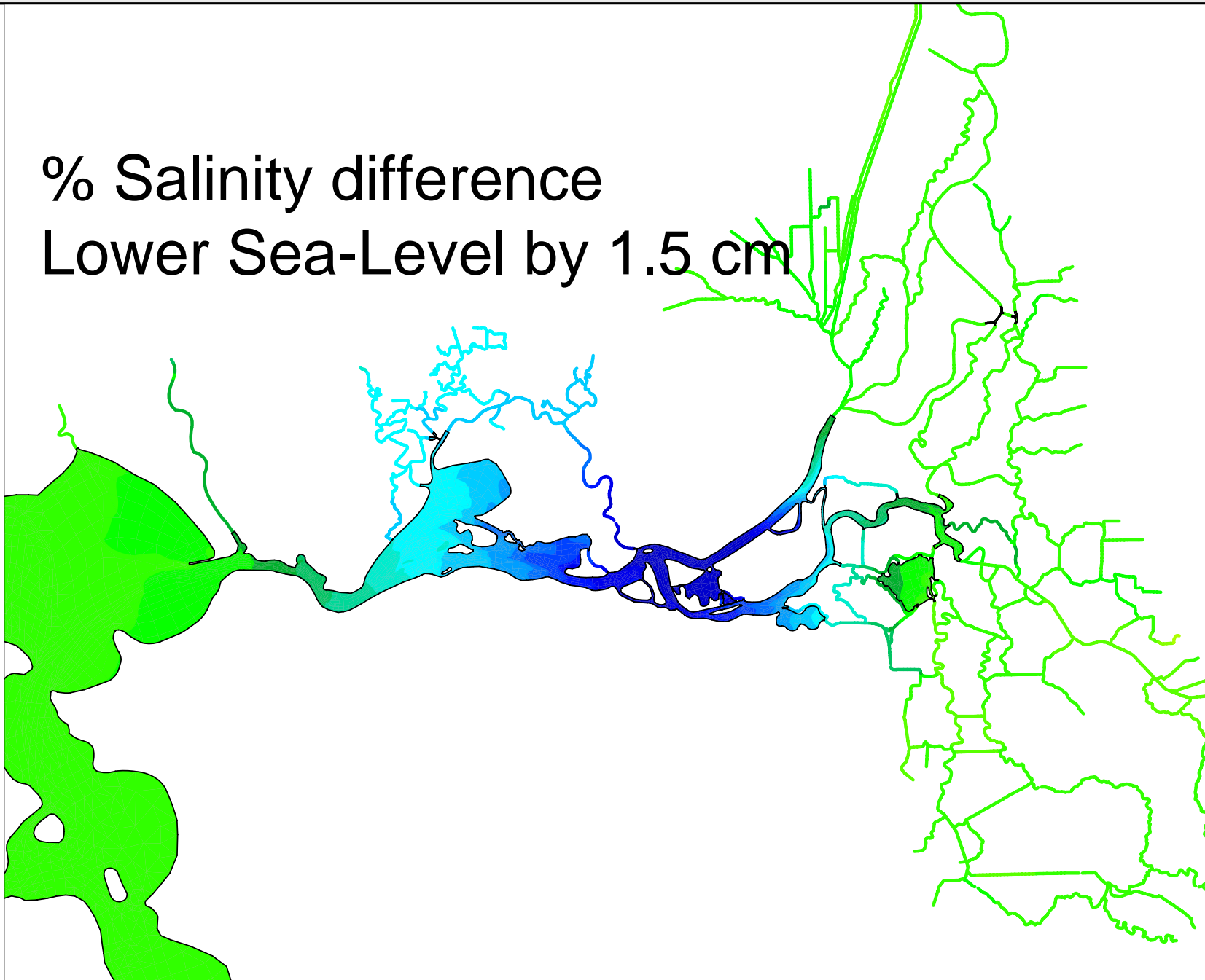
- Sea level was about 1.5 cm lower in 1921

3. Natural and human influence...

% Change

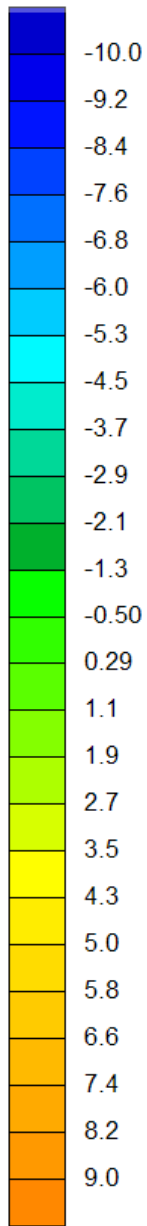


% Salinity difference
Lower Sea-Level by 1.5 cm

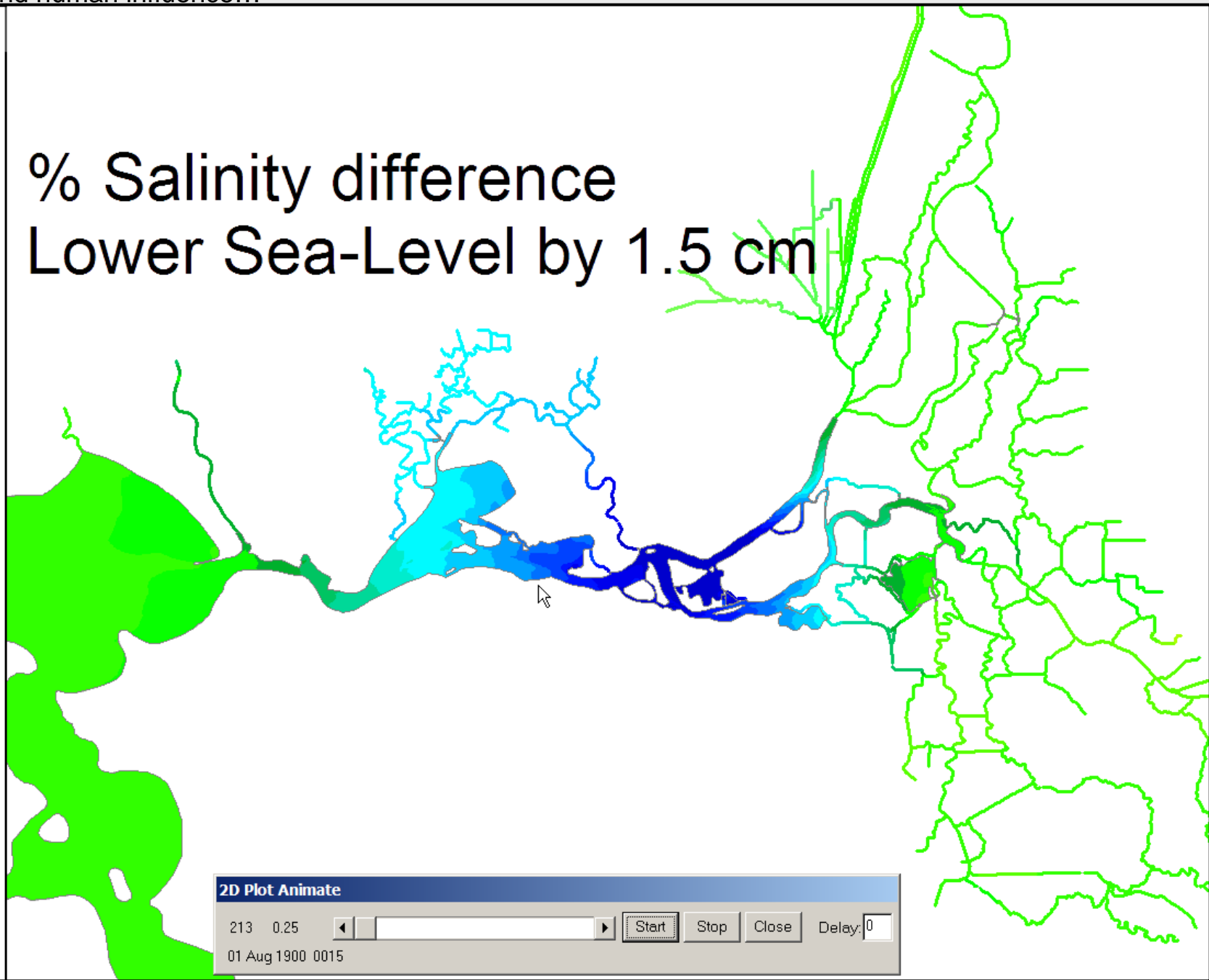


3. Natural and human influence...

% Change



% Salinity difference
Lower Sea-Level by 1.5 cm



2D Plot Animate

213 0.25



Start

Stop

Close

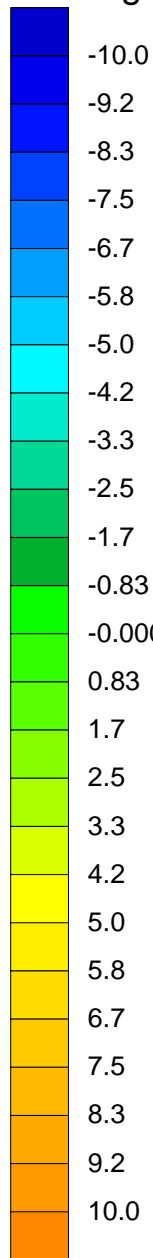
Delay: 0

01 Aug 1900 0015

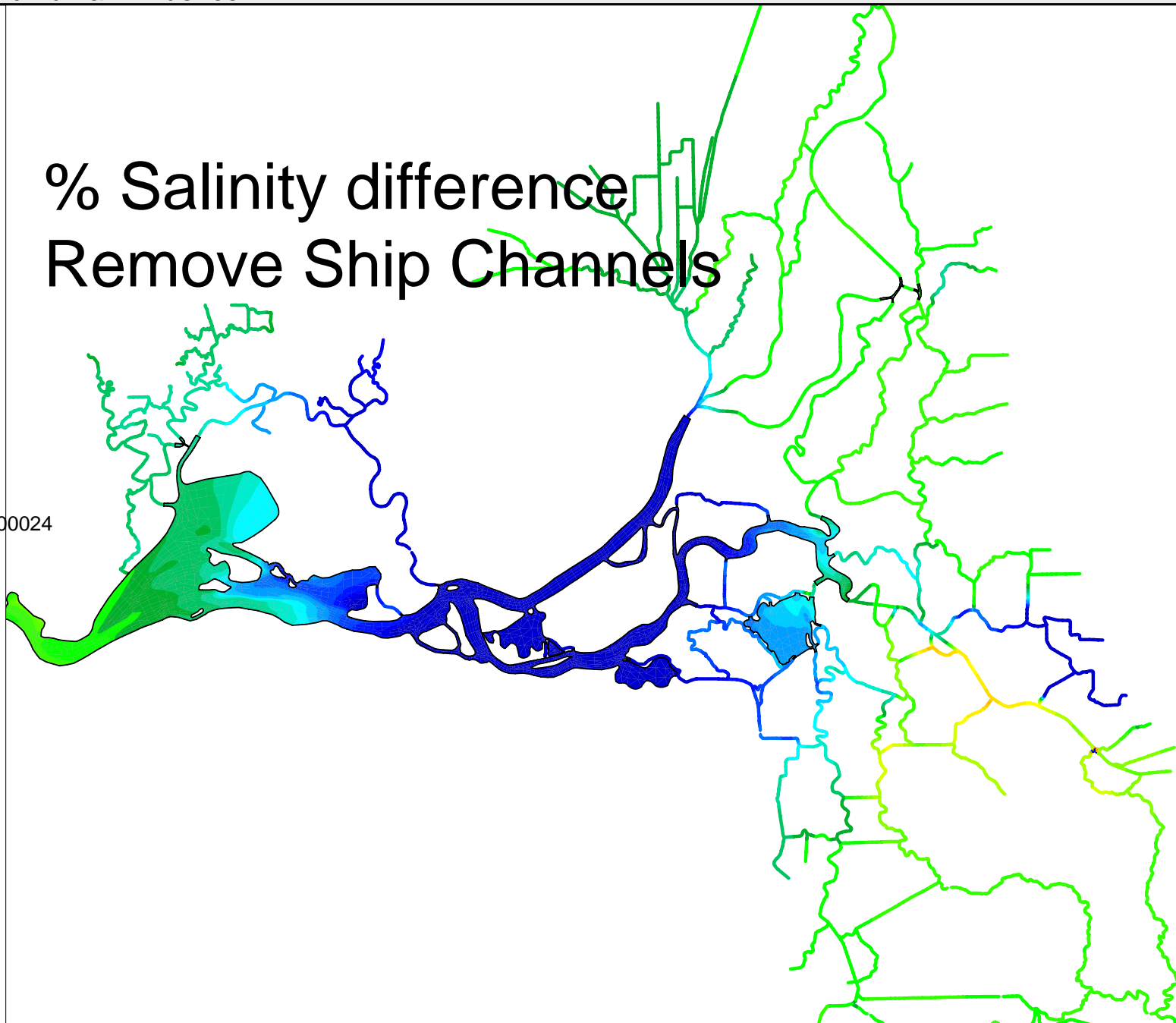
Influence of ship channels on Suisun and Delta salinity

3. Natural and human influence...

% Change



% Salinity difference
Remove Ship Channels



Conclusions

- Outflow and salinity trends are minimal since 1921. Most variability explained by climate.
- The physical geometry of the estuary dissipates tidal energy and disperses salt.
- The estuary geometry has changed through “natural” and human influence.
- The salinity regime of the estuary depends primarily on geometry.

Thank You

- Aaron Miller
- Brad Tom
- John DeGeorge
- Richard Raichele
- Jon Bureau
- Victor Pacheco